QUIETSEAS - Assisting (sub) regional cooperation for the practical implementation of the MSFD second cycle by providing methods and tools for D11 (underwater noise)

D5.1 National barriers and difficulties for the implementation of the TG Noise methodological framework for D11C2

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3	Service hydrographique et océanographique de la marine	Shom	France
4	Politecnico di Milano-Department of Civil and Environmental Engineering	POLIMI-DICA	Italy
5	Hellenic Centre for Marine Research	HCMR	Greece
6	Inštitut za vode Republike Slovenije/Institute for water of the Republic of Slovenia	IZVRS	Slovenia
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Abstract

This document is the Deliverable "D5.1 National barriers and difficulties for the implementation of the TG Noise methodological framework for D11C2 (30th September 2022)" of the QUIETSEAS project funded by the DG Environment of the European Commission within the call "DG ENV/MSFD 2020 call". This call funds projects to support the implementation of the second cycle of the Marine Strategy Framework Directive (2008/56/EC) (hereinafter referred to as MSFD), in particular to implement the new GES Decision (Commission Decision (EU) 2017/848 of 17 May 2017) laying down criteria and methodological standards on Good Environmental Status (GES) of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU) and Programmes of Measures according Article 13 of the MSFD. QUIETSEAS aims to support the practical development of the second implementation cycle under the MSFD for D11 (underwater noise).

The object of this document is to summarize the main difficulties identified for the practical implementation of the TG Noise methodological framework from the technical and management point of view, with special attention to the Mediterranean and Black Sea context.

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List of Abbreviations

CTN	Centro Tecnológico Naval y del Mar
ACCOBAMS	Permanent Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
DFMR	Department of Fisheries and Marine Research
IZVRS	Inštitut za vode Republike Slovenije/Institute for water of the Republic of Slovenia
HCMR	Hellenic Centre for Marine Research
POLIMI-DICA	Politecnico di Milano-Department of Civil and Environmental Engineering
SPA/RAC	Specially Protected Areas Regional Activity Centre
ICES	International Council for the Exploration of the Sea
Shom	Service hydrographique et océanographique de la marine
MHD	Maritime Hydrographic Directorate
MSFD	Marine Strategy Framework Directive
GES	Good Environmental Status
MS	Member State(s)
MED	Mediterranean Sea
BS	Black Sea
CA	Competent Authority
NR	National representative
SO	Specific Objective
TB	Thematic Block

TVs	Threshold values
TG Noise	MSFD Common Implementation Strategy Technical Group on Underwater Noise
LOBE	Level of Onset of Biologically adverse Effects
EN-Noise	HELCOM Experts Network on Underwater Noise
HELCOM	The Baltic Marine Environment Protection Commission (or Helsinki Commission)
JOMOPANS	Joint Monitoring Programme for Ambient Noise North Sea

1. Introduction

The QUIETSEAS Project is funded by DG Environment of the European Commission within the call "DG ENV/MSFD 2020". This call funds MSFD development, in particular, the preparation of the next 6-year cycle of implementation.

The QUIETSEAS project aims to enhance cooperation among Member States (MS) in the Mediterranean Sea Region (MED) to implement the third Cycle of the Marine Directive and in particular to support Competent Authorities and strengthen cooperation and collaboration in the Mediterranean Sea and Black Sea regions through the following specific objectives:

- Specific objective 1 (SO1): To identify relevant indicators for criterion D11C2 (Anthropogenic continuous low-frequency sound in water).
- Specific objective 2 (SO2): To promote the consolidation of relevant indicators for D11 and support the operationalisation of indicators on the state, pressure and impacts of underwater noise in close coordination with TG Noise.
- Specific objective 3 (SO3): To promote harmonisation of regional work on threshold values with TG Noise recommendations.
- Specific objective 4 (SO4): To develop effective and efficient mechanisms for GES assessment and regional coordination by providing management tools for harmonization, reporting and assessment of D11.
- Specific objective 5 (SO5). To demonstrate the potential effectiveness of coordinated mitigation measures to reduce shipping noise.
- Specific objective 6 (SO6): To promote (sub)regional cooperation in order to ensure i) coordination across the region/ subregions ii) the involvement of Competent Authorities iii) long-term dissemination of the results.

To achieve its objectives, the project is divided in 4 work packages (thematic blocks) and 9 activities whose relationships are shown in Figure 1.

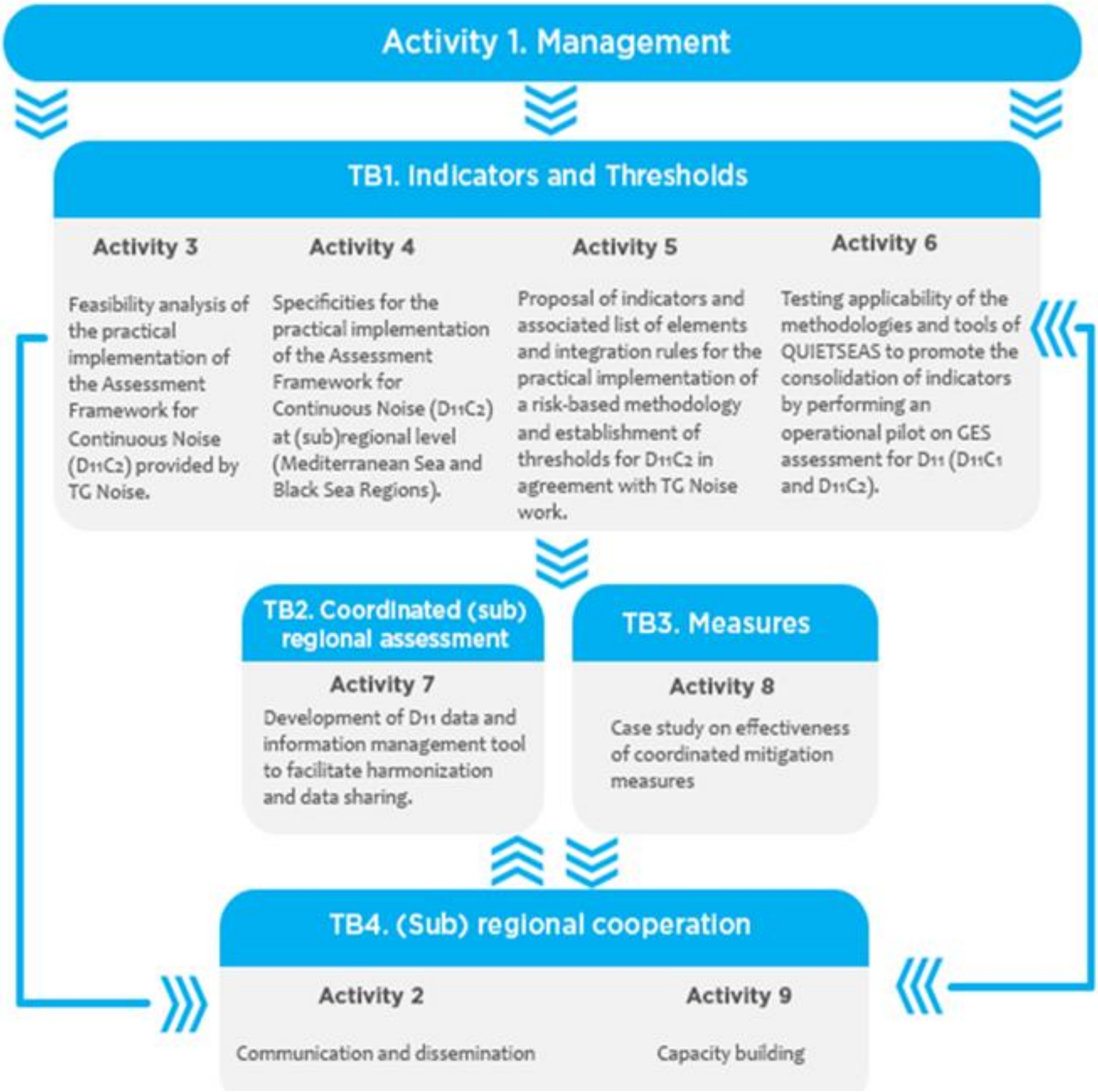

Figure 1. Work plan structure

The project is developed by a consortium made up of 10 entities coordinated by CTN and it has a duration of 24 months starting on 1st February 2021.

2. Main difficulties identified for the implementation of the methodology to establish threshold values and defining achievement the GES

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that good environmental status (GES) is achieved and maintained in European waters by the Member States (MS) of the European Union. The European Commission (Commission Decision 2010/477/EU) expected the achievement and maintenance of GES to take place from 2020. After the evaluation of the first cycle, the European Commission, in order to improve the implementation of the second evaluation cycle, amended the 2008 MSFD and repealed the 2010 decision (Commission Decision 2010/477/EU) with the new Decision 2017/848/EU. Such a decision provides for methodological standards and criteria to help MS determine the GES using standardised methods for monitoring and evaluation.

3. Critical issues in establishing threshold values

The European Commission's 2017 decision requires MS to work with criteria and methodological standards to define threshold values and establish good environmental status by collaborating at European and regional levels in order to ensure consistent implementation of the MSFD. Threshold Values (TVs) contribute as well to the determination of characteristics to define and assess the degree to which MS achieve GES.

One of the critical issues is the consistency required in defining TVs with EU legislation and the specificity considering the different biotic and abiotic characteristics of EU regions, sub-regions and subdivisions (Article 13 2017/848). The definition of EU-wide TVs, taking into account the various sub-regional specificities, could therefore differ between regions or sub-regions, but should still ensure comparability between them. This critical aspect makes the definition of TVs a difficult task for MS.

The new European Commission decision (2017) envisages that the risk-based approach (L 125/44, point 6) will be applied for the TVs assessment framework and the GES definition allowing for regional declinations.

The TG Noise (Technical Group on Underwater Noise), together with the Working Group on Good Environmental Status (WG GES), was mandated by the Marine Strategy Coordination Group (MSCG) in its work programme 2020-2022 to contribute to the harmonised implementation of the MSFD and a common strategy in defining EU TVs for Descriptor 11 (D11C1, D11C2). The TG Noise focuses on developing thresholds related to the indicators described in the MSFD, trying to enhance cooperation between MS and taking into account both regional and sub-regional specificities. The TVs defined should ensure that anthropogenic noise levels do not exceed levels that adversely affect marine animal populations and that the "extent of the assessment area over which TVs have been reached" is reported (Decision 2017/848). Therefore, in order to fulfill the purpose of the GES Decision, it is essential to develop an indicator based on the negative effects on individual animals referring to the effects on populations.

Due to knowledge gaps in presence, sensitivity and response of marine mammals to noise there are difficulties in presenting and defining thresholds. Therefore, the TG Noise defines guidelines providing assessment frameworks and methodologies for the definition of thresholds to be implemented by MS. These approaches must be clearly understandable and transparent so that they can be applied by all MS.

The methodological framework proposed by the TG Noise (TG NOISE, DL3, 2021) provides a sequential approach to define TVs and quantify the area impacted by continuous noise within a habitat.

The sequence of the steps of the framework is the following:

Step 1. Define Indicator Species and their Habitats

Step 2. Define the Level of Onset of Biologically adverse Effects (LOBE)

Step 3. Determine time periods for the assessment

Step 4. Assess the acoustic status by monitoring

Step 5. Establish the Reference Condition

Step 6. Establish the Current Condition

Step 7. Evaluate the condition of the Grid Cells

Step 8. Determine the status of the Habitats

Step 9. Assess the status of the MRU as being GES or not GES.

This type of approach is based on that already published for impulsive noise (D11C1) (Heinis et al., 2015; Merchant et al., 2018; OSPAR, 2017; Dekeling et al., 2020).

The methodology allows the assessment of the acoustic background status relative to continuous noise by using only modelling or only measurements or a combination of them, the last option being proposed as the best way (see Dekeling et al, 2014, pages 21, 40; TG NOISE, DL3, 2021, Annex 5). The new Commission decision (L 125/45, point 13) requires TVs to be set in relation to a reference condition. This is addressed in Step 5 (Establish the Reference Condition) of the aforementioned sequential steps. The reference condition is related to the natural state dominated by sound that varies depending on biological activities, geological processes, meteorological and hydrological parameters (for a more specific definition, see TG Noise, DL3, 2021, p. 10). From the assessment of the current condition (including both natural and anthropogenic sounds) and the definition of the reference condition in a habitat, it is possible to estimate how much the habitat is affected by anthropogenic noise. All assessments are made on the basis of appropriate metrics, using particular temporal and spatial scales defined at a regional or sub-regional level. The proposed methodological framework considers as significant effects both masking (i.e. potential loss of communication space for indicator species due to continuous noise) and disturbance (i.e. behavioural effects observed in relation to specific sound pressure levels). Finally, the status of the selected habitats will be determined (Step 8) based on an evaluation of the status of the grid cells (Step 7), assuming that potential negative effects occur at the population level when a certain fraction of habitat is exposed to continuous noise above a Level of Onset of Biologically adverse Effects (LOBE) for a certain fraction of time.

Within this framework, the most critical aspects are the following:

1. The definition of one or more representative (or indicator) species that are considered sensitive to noise and representative for the marine area can be challenging with heterogeneous Marine Reporting Units;
2. The identification of the habitats, defined as the “areas where the indicator species live”, for which there may be not enough knowledge in all the regions;

3. The setting of LOBE, representing “a sound level above which effects on indicator species are expected to affect their well-being, survival and reproduction" (TG NOISE, DL3, 2021); LOBE is strongly dependent on the indicator species; however, present knowledge does not homogenously cover all the potential species of interest.
4. Steps 8 and 9 concern TVs in terms of “Tolerable impacted area of the habitat” and “Tolerable duration of the noise” (see TG NOISE, DL3, 2021, p. 10, for definitions). Also, in this respect, available knowledge is poor for most of the species of interest and of marine areas.

In this DL3 Assessment Framework, the selection of habitats and indicator species, the definition of LOBE, the choice of the assessment method (modelling, measurement or combination) and the metrics to be used (DL3, Annex 6) are all decisions that need to be made sub-regional level, with the ambition to take into account regional specificities.

This requires a great deal of effort on the MS part in cooperating on the applicability of the methodology and the definition of TVs. Not to be forgotten are also the lack of standardization in the development of protocols for data collection/ management, as well as the heterogeneous available resources and experience/ preparation in policy implementation.

4. Knowledge gaps for the establishment of the thresholds in Mediterranean and Black Sea area

As already explained, a sound scientific knowledge is required[1] for the definition of TVs and the application of the proposed methodology.

It is known that noise negatively affects marine mammals through different mechanisms. Indeed, many studies have targeted these species as particularly sensitive to noise (i.e. Southall et al., 2007, 2019; Erbe et al, 2011, 2012, 2018). Despite this, due to an increasing concern about the impact of noise on the marine environment, several other studies are targeting fish and marine invertebrates (Hastings, 2005, 2008; Popper et al., 2005, 2009; Popper and Hawkins, 2014, 2016) even though they are still much fewer than the marine mammal studies.

The effects generated by continuous noise on marine mammals considered in TG Noise methodological framework, are masking of communication and behavioural responses. However, estimating masking or behavioural effects caused by continuous noise is a quite complex task and it requires detailed knowledge of both the sources of anthropogenic noise and the ecological characteristics of indicator species as well as their sensitivity to noise. Considerable gaps still exist in this respect, although ongoing studies on these factors will certainly fill most of existing knowledge gaps.

On the other hand, at the current status, the definition of TVs will require to collate together existing knowledge and scientific evidence with future knowledge deriving from ongoing studies, in order ensuring the integration of new evidence during implementation, to meet the requirements of the MSFD.

4.1. Knowledge gaps in the representative/indicator species and habitat selection

One of the critical issues concerns knowledge gaps with respect to the representative/indicator species that should be selected by the MS for the application of the threshold-setting methodology.

4.1.1. Mediterranean Sea Area

The Mediterranean Sea has a high biodiversity: highly diverse habitats, ecological niches and hydrological and climatic aspects specific to the basin (Fredj et al., 1992). The Mediterranean also has a diverse bathymetry, ranging from shallow to deeper areas with very steep continental slopes. Precisely because of this heterogeneity, the Mediterranean has a wide variety of habitats and hence diversity in the species.

[1] "Criteria, including threshold values, methodological standards, specifications and standardised methods for monitoring and assessment should be based on the best available science" (Commission Decision 2017 - paragraph 20 L 145/46).

As far as cetaceans are concerned, different species of odontocetes and mysticetes can be found in the Mediterranean Sea region. Nine species are considered resident (or regularly present) within the basin (Notarbartolo di Sciara et al., 2016) and, among odontocetes they are: striped dolphin (*Stenella coeruleoalba),* bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), Cuvier's beaked whale (*Ziphius cavirostris*), long finned pilot whale (*Globicephala melas*), sperm whale (*Physeter macrocephalus*) and harbour porpoise (*Phocoena phocoena relicta*). Fin whale (*Balaenoptera physalus*) is the only regular species concerning mysticetes. Other species such as the orca (Orcinus orca), false killer whale (Pseudorca crassidens) and Indian ocean humpback dolphin (Sousa plumbea) are classified as limited and occasional odontocetes in the Mediterranean Sea (Fontaine, 2016; Esteban et al., 2016; Frantzis, 2019); while humpback (*Megaptera novaeangliae*) and common minke whale (*Balaenoptera acutorostrata*) (Frantzis, 2019) are rare and occasional mysticetes. The rough-toothed dolphin (*Steno bredanensis*) is also present, mainly sighted in the eastern part of the basin, but current data are insufficient to establish its distribution (Palialexis et al., 2018).

The selection of representative/indicator species and corresponding habitat is made at MS level. When those species are chosen as representative for more than one MS, they may be considered indicator species at the regional/sub-regional level. The knowledge on the occurrence and distribution of species in different countries, but also at sub-regional level, within the Mediterranean is very diverse and heterogeneous, making the selection of species and habitat difficult. This affects especially the implementation of a harmonised methodology for TV definitions as well as the comparison of the GES. Therefore, at the Mediterranean level, there is not sufficient and comprehensive data, nor on the abundance and distribution of species, nor on the extent and condition of habitats where the most critical life stages (foraging, reproduction, migration) take place.

Many MS have employed and allocated resources to carry out monitoring in the Mediterranean area, but one of the main problems is the lack of standardisation in monitoring protocols. Indeed, the protocols differ in the time of survey coverage (long or short term), the seasonal period, the type of monitoring carried out (visual, acoustic) or the type of medium used (marine, aerial). These differences make it difficult to compare the collected data and the results obtained.

In order to improve the knowldege and to fill knowledge gaps related to the species and their habitats, monitoring campaigns have been conducted. ACCOBAMS (Agreement on the Convention on Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic Area) launched the Aerial Survey Initiative (ASI) in 2018 campaign for a large-scale cetacean monitoring activity. Surveys carried out in the Mediterranean area offered the possibility of collecting more data on the presence and distribution of cetaceans, but they are insufficient to estimate abundance for all species present within the basin.

ASI data have certainly contributed to improve the knowledge on the distribution of cetaceans on a large scale, facilitating the comparison of TVs and GES across sub-regions. Nevertheless, to have a more complete picture about the distribution of marine mammals, these synoptic short-term campaigns should be complemented by long-term small-scale data collections.

In the Mediterranean Sea, there are also differences regarding survey efforts between the different Mediterranean sub-regions, mainly between the north-central and southern areas where fewer survey programmes have been conducted (Mannocci et al., 2018). Further surveys would therefore be necessary to broaden the coverage of the entire area, covering also the different seasons throughout the year. In addition, the surveys should follow a standardised procedure in order to make the monitorinjg activities comparable.

4.1.2. Black Sea Area

The Black Sea is a closed basin with areas of deep water, steep slopes adjacent to land and submarine canyons (Murray et al., 1989).

The Black Sea has a particular characteristic: the surface layer (within 200 m) is well oxygenated, while the deeper layer (between 200 and 2000 m) is anoxic. So, approximately 87% of the Black Sea waters are anoxic with low salinity levels (Sanchez-Cabanes et al., 2017). Despite to that, Black Sea hosts a wide variety of habitats, although their biodiversity is relatively low (Oguz and Ozturz, 2011, Selifonova, 2011). Only three cetacean species can be regularly found in the Black Sea, which are also distinct subspecies from those of the Mediterranean Sea, being endemic to the Black Sea: The Black Sea common dolphin (*Delphinus delphis ponticus*) (Barabash 1935), the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) (Barabash-Nikiforov 1940) and the Black Sea porpoise (*Phocoena phocoena relicta*) (Abel 1905) (Sánchez-Cabanes et al., 2017).

Comprehensive surveys to estimate the abundance of these species for the entire Black Sea have not been conducted since the 1980s (Paiu et al., 2021). In addition, some of the older aerial and marine surveys were conducted for short periods of time or covering small portions of the basin's area, thus not being sufficient for reliable abundance estimates (Bucland et al, 1992; Sánchez-Cabanes et al., 2017). Over the last decade, monitoring has been implemented to have more consistent data about abundance and distribution of the Black Sea cetacean species (Raykov and Panayotova 2012, Radu et al. 2013). Many studies, however, have not been made available (Sánchez-Cabanes et al., 2017), making it difficult to use their results to complement the knowledge acquired during the more recent surveys, to improve the understanding on population sizes, distributions and the main ecological driving factors concerning the Black Sea region. Furthermore, as for the Mediterranean Sea, the monitoring protocols were not standardised, concerning different periods, durations and using different platforms and different types of monitoring.

To implement and fill in the gaps, ACCOBAMS carried out the ASI aerial survey initiative for cetacean monitoring in the Black Sea as well, with the CeNoBS Project carried out in 2019. CeNoBS project was meant to support the implementation of the MSFD in the Black Sea through the establishment of a regional cetacean monitoring system (D1) in addition to a noise monitoring (D11) for the achievement of the GES. Together with the CeNoBS project, the EMBLAS-Plus project, conducted in Russian waters, also allowed data to be collected in areas of the basin not covered by the CeNoBS project. These short-term, large-scale aerial surveys enabled the collection of important data, which also allowed an initial analysis of the distribution and abundance of the three species (Paiu et al., 2021).

The ASI data significantly contribute to integrate the available information on the Black Sea species and allow the comparison of TVs and GES in the different marine areas. Nevertheless, deriving from synoptic short-term surveys, they lack temporal dimension and they should be complemented by further small-scale, regional, and long-term monitoring, to increase the period of assessment, possibly considering also autumn and winter months and not only the summer season.

4.2. Knowledge gaps on the impacts of continuous noise on representative/indicator species and assessment of consequences for the population

A key step in defining TVs is to know the noise levels that adversely affect the indicator species. Noise is capable of causing an impact on cetaceans (Southall et al., 2007, 2019; Weilgart, 2017; Slabbekoorn et al., 2018; Gordon, 2018; Erbe et al, 2018, 2019;) through different mechanisms. Noise exposure has been shown to cause damage at both anatomical and physiological level (biological tissues, auditory receptors, cardiovascular or hormonal effects), at the level of communication and masking, but also within the behavioural stage or, in the most severe cases, even lead to the death of the animal (Wright et al., 2007; Novacek et al., 2007; Southall et al., 2007; Merchant et al., 2014; Gomez et al., 2016; Munzel et al., 2020). Particularly, for continuous noise, physiological and anatomical effects are less relevant as the received noise levels are not sufficiently prolonged or high due to the sources (e.g. ships). Many studies for continuous noise indeed investigate more the effects of masking communication and passive listening and behavioural disturbance (Erbe, 2015; Erbe et al., 2016; Blair et al., 2016). For both, one of the main difficulties concerns knowledge about the different levels of vulnerability of species, that is, species-specific variations in hearing ability and sensitivity to noise.

Furthermore, masking caused by increased levels of underwater noise is difficult to estimate as it requires a lot of knowledge about the distance from the noise source to the receiving animal, information about the signal undergoing masking and the noise source (Erbe, 2015; Erbe et al., 2016). The assessment of noise disturbance is also a complex procedure as a change in the animal's behaviour must be assessed in which the behavioural context and previous experiences with noise that may lead to habituation, and sensitisation must be taken into account.

Many of the studies dealing with these issues concern species that do not belong to the Mediterranean and Black Sea areas, or studies carried out in captivity, making knowledge about the sensitivity and vulnerability of species limited. Some studies carried out on species present in the areas of interest concern bottlenose dolphins (Buckstaff, 2004; Jensen et al., 2009; Rako et al., 2013) sperm whales (Azzarra et al., 2013), long finned pilot whales (Jensen et al., 2009), fin whales (Clark et al., 2009; Castellote et al., 2012), Cuvier's beaked whales (Aguilar Soto et al., 2006) and harbour porpoises (Tougaard et al., 2015). These studies are summarised in Table 1.

SPECIES	YEAR	AUTHOR	STUDY AREA	Main findings
Bottlenose dolphins	2004	Buckstaff	Florida (Atlatic Ocean)	The study concerns a resident community of about 140 individuals near Sarasota, Florida, exposed to a vessel passing within 100 m approximately every six minutes during daylight hours. Changes in vocalisation have been observed such as an increase in whistle repetitions as the vessel approaches. This may be a way to compensate for signal masking by maintaining communication in a noisy environment.
Bottlenose dolphins, Long finned pilot whales	2009	Jensen et al.	Tenerife, Canary Islands (Mediterranean)	Digital acoustic tags are used to demonstrate that free-ranging delphinids in a coastal deep-water habitat are subjected to varying and occasionally intense levels of vessel noise. Small vessels in shallow water can reduce the communication range of bottlenose dolphins within 50 m by 26%. Pilot whales in a quieter deep-water habitat could suffer a reduction in their communication range of 58%.

Bottlenose dolphins	2013	Rako et al.	Croatia, Adriatic Sea (Mediterranean)	The waters of the Cres–Lošinj archipelago (Adriatic Sea) are subject to intense boat traffic. Boat noise dominates the acoustic environment of the local bottlenose dolphin (*Tursiops truncatus*) population. Dolphin distribution indicated significant seasonal displacements from noisy areas characterized by the intense leisure boating.
Sperm whales	2013	Azzarra et al	Gulf of Mexico (Atlantic Ocean)	This analysis explored whether sperm whales respond to the passage of vessels using changes in total number of clicks during vessel passages as a proxy for potential variation in behaviour. Results indicate a significant decrease (32%) in the number of clicks detected as a ship approached an area. There were also significantly fewer clicks detected after the vessel passed than before (23%).
Fin whales	2009	Clark et al.	Gulf of California, (Pacific Ocean); Mediterranean Sea	This paper presents an analytical paradigm to quantify changes in an animal's acoustic communication space as a result of spatial, spectral, and temporal changes in background noise, providing a functional definition of communication masking for free-ranging animals and a metric to quantify the potential for communication masking. The proposed paradigm and mechanisms for measuring levels of communication

				masking can be applied to different species, contexts, acoustic habitats and ocean noise scenes to estimate the potential impacts of masking at the individual and population levels.
Fin whales	2012	Castellote et al.	Strait of Gibraltar, Alboran basin, Balearic basin, and Provençal basin, (Mediterranean)	Fin whale songs and behaviour are modified in response to shipping and airgun noise. Temporal and spectral song features decreased in high noise conditions. Fin whale communication is modified to compensate for increased background noise.
Cuvier's beaked whales	2006	Aguilar Soto et al.	Ligurian Sea (Mediterranean)	This paper reports data from a small set of foraging dives, one of which has a markedly shorter vocal phase and therefore a lower foraging efficiency that coincides with a noisy vessel passage. It is demonstrated that ship noise can lead to elevated ambient noise levels at high frequencies with the potential of masking toothed whale echolocation and communication.
Harbour porpoises	2015	Tougaard et al.	General	The results from TTS (temporary threshold shift) experiments and field studies of behavioural reactions to noise, suggest that response thresholds and TTS critically depends on stimulus frequency. Sound exposure levels for pure tones that induce TTS are reasonably consistent at about 100 dB above the hearing threshold for pure tones and sound pressure thresholds for avoidance

				reactions are in the range of 40–50 dB above the hearing threshold.

Table 1: Recap of the most relevant studies cited within this document.

Anthropogenic noise produces effects on individuals and populations by altering cetacean habitat (National Researcher Council, 2003; Campana et al., 2015). Defining the long-term effects that noise can cause a population of animals is important from a conservation perspective to assess the consequences on welfare, survival and reproduction. The cumulative effect of many disturbances and behavioural changes would in fact lead to an expenditure of energy to respond to noise at the expense of other vital behaviours such as foraging, socialising or resting, with consequences for survival and reproduction (Ellison et al., 2012; Southall et al., 2007, 2019). The assessment of these types of effects requires a high level of knowledge about animal behaviour and vulnerability. Furthermore, it is crucial to consider those areas where animals perform functional activities such as feeding, reproduction and migration, and to assess what the impact is on these more sensitive areas (Southall et al., 2007, 2019). The negative effects may therefore vary depending on the location and period under consideration. This therefore complicates the definition of thresholds, as habitat areas that include functional activities, migratory areas and temporal variation must be considered.

To improve the knowledge, more studies should be conducted on the bioacoustic characteristics and hearing thresholds of Mediterranean and Black Sea species to complement those deduced from other studies carried out in other areas or in captivity.

Another possibility to increase studies and knowledge about cetaceans and continuous underwater noise would be to use passive acoustic devices in different areas capable of recording the environment bioacoustic characteristics (Vella et al., 2018). This would provide data on underwater noise, but also on the presence/absence of cetaceans in relation to different levels of noise present, improving understanding of the sensitivity and vulnerability of the species.

4.3. Difficulty in defining the Level of Onset of Biologically adverse Effects (LOBE)

The LOBE is a sound pressure level above which biologically significant effects may occur for the selected indicator species (TG NOISE, DL3, 2021), thus demarcating areas having significant effects from those that do not. Above this level, higher risks of effects are expected that may ultimately affect animal reproduction and welfare.

LOBE, however, can be considered in two different ways depending on how the impact is intended. When considering masking, LOBE is considered as a noise level in excess of the reference condition, while when considering behavioural response it is defined as a fixed level of the current condition above which a biological response occurs. In both cases, the level should preferably be determined on the basis of empirical evidence from studies on indicator or closely related species (TG Noise, DL3, 2021).

Defining LOBE is therefore an important step, which is rather complicated, as specified in the previous chapter, given that knowledge about masking and behavioural disturbances in relation to continuous noise is limited.

There are several studies on marine mammals concerning behavioural responses to different levels of received noise (RL in dB re1 µPa). Some of these, such as Southall et al., 2007, 2019, explore the dose-responses of marine mammals to noise by classifying behavioural changes into a severity scale (based on 9 categories) ranging from mild and brief reactions to stronger and more important responses. This severity scale was also used in the review by Gomez et al. (2016), revisiting and adapting it. Both studies consider cetacean species by dividing them according to hearing ability, since an important issue in this context is indeed species-specific differences in both hearing ability and sensitivity. From the review by Gomez et al. (2016), the results seem to show that 100-110 dB re 1 µPa could be considered as the received level at which behavioural responses begin to occur. Some studies on grey whales (*Eschrichtius robustus*), on the other hand, used 120 dB re 1 µPa as the average received level (SPL sound pressure level) above which biological responses begin to occur (Malme et al., 1983, 1984). SPL values of 120 dB re 1 µPa are also used by the National Marine Fisheries Service (NOAA 2019) and the ACCOBAMS guidelines (ACCOBAMS, 2013). Despite these attempts to evaluate dose-response relationships for behavioural responses, there is still no consensus on which levels to consider. Another key issue to be addressed is that responses can be highly variable, as they depend on factors such as the ecological context, but also previous experience with noise that may influence the animals' sensitisation or lead to habituation.

Masking, as explained in the previous chapter, presents many problems as well. Marine mammals produce sounds that are associated with reproduction, feeding, socialisation, rearing young and group cohesion (Erbe et al., 2016, 2019). Underwater noise can therefore influence how marine mammals receive acoustic signals. Masking levels are therefore difficult to predict for any combination of sender, receiver and environment. To date, there are no species with complete knowledge of its masking models (Erbe et al, 2016).

In addition, the frequencies in the one-third octave band centered on 63 and 125 Hz were chosen in the MSFD, since they are the most affected as regards continuous (mostly shipping) noise. These frequencies, however, could be strongly influenced by environmental noise related to currents and tides. In addition, available audiograms show that most odontocete cetaceans are insensitive to these frequencies, whereas they may be significant for mysticete cetaceans that use low frequencies to communicate. However, data on these species in the Mediterranean area are lacking compared to those of odontocetes. For these reasons, considering the MSFD guidelines, the 2000 Hz frequency could be monitored in addition to the above-mentioned ones. At present, however, only a few states (such as Finland) have implemented monitoring of this frequency band as well (Vighi et al., 2021).

Another issue to consider is the ability of cetaceans to modify vocalisations to compensate for the underwater noise (Parks et al., 2010). These 'anti-masking' reactions by the sender alter vocal behaviour by changing parameters such as level, repetition and intensity, collectively known as the Lombard effect (Lombard, 1911, Erbe et al., 2016). Masking is therefore a highly complex phenomenon to study and whose levels are difficult to predict.

5. Difficulties in determining and assessing habitat status

The main point of the methodology is the selection of indicator species for which the habitat is to be assessed, on a regional or sub-regional level, in relation to possible noise impacts. The habitat is to be understood as the “geographical domain, i.e. the area occupied by the species or species community” (TG NOISE, DL3, 2021, in relation to Directive 92/43/EEC). In order to assess the status of the habitat, this is divided into cells called “grid cells”. An important issue, as there is no suitable size for all European marine areas, is the decision on the cell size, which is defined on a regional or sub-regional level taking into account regional specificities. This could lead to a difficult comparison of results, therefore TG Noise recommends the use of existing grid definitions (TG Noise, DL3, chapter 4, 2021).

Habitat status is assessed in terms of tolerable impacted area and tolerated duration by aggregating the grid cell states. One difficulty is that TVs for defining the tolerable habitat status needs to be formulated at the European level, thus with a shared decision in order to have comparable TVs.

Impacted habitat can be quantified based on the assessment of the reference condition and of the current condition of the cell. In both cases, decisions on the temporal and spatial scales to be used to monitor and assess such two conditions are defined at the sub-regional or regional level. The main issues concern the monitoring of the current condition since for anthropogenic noise, comprehensive information on vessel traffic and other relevant continuous noise sources is required. To assess noise caused by vessel traffic, it is possible to refer to AIS data obtained from the Automatic Vessel Identification System, and VMS data on fishing vessels that collect information on vessel routes and speed. These data, together with physiographic and environmental data, will be used to build sound propagation models for assessing the acoustic status of the habitat and the potential impact on cetacean populations. An important issue is that not all vessels, such as recreational boats, possess AIS systems, making such information incomplete, especially in the sub-shore areas where these types of vessels are most concentrated. It has been found that even in deep sea areas, data are limited and with low confidence. For these reasons, the assessment of the acoustic status could be very complex for some MS, especially in certain areas, making the subsequent definition of TVs difficult due to the uncertainty of the available data. Possible solutions offered by TG Noise involve the use of shore-located radars (those responsible to track small vessels) to be integrated with AIS data, while in-situ measurements and recordings could be integrated to gain more confidence in modelling offshore data. In any case, modelling needs direct measurements to be validated.

It must also be considered that in-situ measurements could be used by MS as the only solution for assessing the noise state without resorting to modelling. In any case, measurements would require a considerable technical and financial commitment on the part of the MS to assess the noise status at regional or sub-regional level.

The use of recorded data from existing facilities and observatories (e.g. NEMO SN1, Sicily) could help in the assessment of the acoustic status and the validation of the modelling performed. However, these facilities are not present in many areas and may not be able to cover the assessment area under consideration, making further measurements necessary.

The use of a platform on which to share modelling and measurements made could be a key element to help MS in the assessment of noise status, especially in areas where it is more difficult to collect data, in order to assess the impacted habitat and compared it with TVs.

6. Barriers in data availability and management

The implementation of the MSFD requires MS to cooperate in collecting and uploading data to databases and portals through a standardized methodology. Some of the difficulties are related to legal constraints faced by the competent authorities in implementing the MSFD.

For impulsive noise, a noise register has been set up in the Mediterranean area (INR-MED) where Member States can upload data in order to increase the sharing of information on anthropogenic impulsive noise. A portal with the same purpose could also be created for continuous noise. Standardisation of procedures for producing and archiving data from measurements and modelling results should be of particular concern. Such an example is the agreement made between HELCOM and ICES for the latter to host ambient underwater noise data. The continuous underwater noise submission format has been agreed by the ICES Data Centre, JOMOPANS and EN-NOISE. Furthermore, one of the main obstacles would be the different methods of managing regional monitoring processes and data sharing by Member States. Therefore, it would be necessary to support the management, harmonisation, data sharing and reporting on continuous noise by providing common tools to share data on a regional level in order to consider activities that generate underwater noise as well as their relative temporal and spatial occurrence.

Another important issue to be addressed would be the confidentiality of monitoring data that may affect the implementation of national portals and the ACCOBAMS portal for the assessment of continuous noise.

7. Portal for data harmonisation and sharing

A portal for the implementation of cetacean conservation management is being developed by ACCOBAMS. Together with biodiversity data, particularly concerning marine mammals, noise data will also be uploaded. Maps made in relation to the distribution of continuous noise levels will be overlaid with those of the species' habitat. This will make it possible to identify indicators concerning the extent of noise risk areas for marine mammals.

The portal will be implemented and tested as a tool for assessing continuous noise. It will facilitate the management and sharing of continuous noise data to support the implementation of the second cycle of the MSFD in the Mediterranean and Black Sea. In addition, ICES will ensure harmonisation of data protocols with HELCOM and North Sea regions facilitating comparison with other European regions.

The noise data to be submitted and subsequently uploaded by ACCOBAMS to the platform are noise maps and SPL values from measuring stations. The Mediterranean and Black Sea countries should submit this continuous noise data annually.

One of the main problems concerns the production of noise maps, which MS may create using different methodologies and standards, thus leading to unreliable comparison of results. For this reason, the format of the data, but also the reporting format of the data and metadata as well as the additional information required should be defined by a common protocol. Requiring detailed information allows for a better understanding of the data and a better utilisation. On the other side, requiring a lot of information may lead some countries to refrain from sending data due to a lack of necessary information. Some other countries might not be able to provide the requested information. On the other hand, sending data with little information would not allow for proper use. Another important aspect is to allow the possibility of improving the quality and resolution of submitted data so that the implementation and evaluation process is increasingly efficient.

In order to compare and evaluate data at a regional level, it would be necessary to have data on a quantitative and qualitative level that can be compared to a sub-regional level. One of the main concerns for the implementation of the platform is the lack of obligations for MS to send data and report information on noise. In addition to this, it would also be necessary to ensure sufficient time to properly inform the MS about the type of information required so that it is consistent with the implementation of MSFD and the definition of TVs.

Finally, the information on the platform should be fully accessible to the research community and facilitate the assessment of continuous noise at regional level.

8. Recommendations

The recommendations for defining TVs in the Mediterranean and Black Sea regions are:

- Increase knowledge about species diversity in the Mediterranean and Black Sea regions, considering the presence of optimal habitat for species at the regional level.

- Increase knowledge about indicator species and their response to continuous underwater noise (at which sound level masking of communication and behavioural responses begin) in the Mediterranean and Black Sea regions.

- Increase knowledge about indicator species habitats in the Mediterranean and Black Sea regions, where animals perform functional activities such as, feeding, reproduction and migration.

- Member States must continue to fill knowledge gaps, including data masking and disturbance effects, implement methods to assess population effects and conduct studies aimed to evaluate the efficacy of the proposed TV on the target species population.

- Member States must continue to implement underwater sound measurements and noise propagation modelling to complement and improve data quality.

- Member States should apply long-term surveys/monitoring of abundance and distribution of indicator species and sizes of their habitats in the Mediterranean and Black Sea regions, using standardised methods in order to make the collected data from monitoring comparable between MS.

- Member States should promote and practically support the implementation of platforms through relevant initiatives and agreements, such as the ACCOBAMS platform (NETCOBAMS), on which to upload data of measured and modelled underwater sound levels as well as data on abundance and distribution of indicator species and sizes of their habitats to facilitate the assessment of continuous noise and the assessment of impact of continuous underwater noise on the indicator species and their habitats.

9. Conclusions

This Deliverable (5.1) with reference to Activity 5 of the QUIETSEAS project, had as its main aim to examine national and regional barriers and difficulties in defining TVs for criterion D11C2 (continuous noise) for the Mediterranean and Black Sea area.

The methodological framework for defining TVs, as proposed by TG Noise (TG Noise, DL3, 2021) implies the treatment of specific critical issues for the Mediterranean and Black Sea Member States, such as:

- Gaps and different levels of knowledge regarding the presence and distribution of sensitive target species in the Mediterranean and Black Sea regions among Member States.

- Knowledge gaps regarding the behavioural response and masking of communication of sensitive target species to continuous noise.

- Gaps and resulting uncertainties in defining biologically significant effects and impacts on populations of sensitive target species.

One of the main obstacles is that Member States show differences in both the implementation of policy and the management of regional monitoring procedures, such as the collection of data and information essential for establishing TVs.

The implementation of a platform to upload data of measured and modelled underwater sound levels as well as data on abundance and distribution of indicator species and sizes of their habitats as a tool for the assessment of continuous underwater noise and its impact on the indicator species and their habitats could be one of the essential steps to improve information sharing and management of sub-regional and regional level.

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