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DELIVERABLE 6.1

National barriers and difficulties for the establishment of thresholds (summary report)

Deliverable: D6.1. National barriers and difficulties for the establishment of thresholds (summary report)

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11	International Council for the Exploration of the Sea	ICES	Denmark

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Abstract

This document is the Deliverable "D6.1. National barriers and difficulties for the establishment of thresholds" of the QUIETMED2 project funded by the DG Environment of the European Commission within the call "DG ENV/MSFD 2018 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 of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU) and Programmes of Measures according to Article 13 of the MSFD.

The QUIETMED2 project aims to support Member States Competent Authorities in the Assessment of the extent to which GES on Descriptor 11-Underwater noise has been achieved in the Mediterranean Region by providing practical outcomes to implement the new GES Decision through: i) a joint proposal for an indicator of the risk of impact caused by impulsive noise in the Mediterranean Region ii) a common methodology for Competent Authorities to establish thresholds values, together with associated lists of elements and integration rules, iii) a data and information tool to support the implementation of the monitoring programmes on impulsive noise based on the current ACCOBAMS joint register which will be demonstrated on iv) an operational pilot of the tool and v) several activities to boost current regional cooperation efforts of Barcelona Convention developing new Mediterranean Region cooperation measures.

The main goal of this document is to summarize the main difficulties identified for the definition and establishment of thresholds form the technical and management point of view, with special attention to the Mediterranean 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
IOF	Institute of Oceanography and Fisheries
UM	University of Malta -The Conservation Biology Research Group
POLIMI-DICA	Politecnico di Milano-Department of Civil and Environmental Engineering
SSW	Special Secretariat for Water-Hellenic Ministry of Environment and Energy
SPA/RAC	Specially Protected Areas Regional Activity Centre
ICES	International Council for the Exploration of the Sea
MSFD	Marine Strategy Framework Directive
MSCG	Marine Strategy Coordination Group
GES	Good Environmental Status
MS	Member State(s)
MED	Mediterranean Sea Region
CA	Competent Authority
NR	National Representative
INR	Impulsive Noise Registry
SO	Specific Objective
TVs	Threshold values

1 Introduction

The QUIETMED2 Project is funded by DG Environment of the European Commission within the call “DG ENV/MSFD Second Cycle/2018”. This call funds the next phase of MSFD implementation, 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 of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU) and Programmes of Measures according to Article 13 of the MSFD.

The QUIETMED2 project aims to enhance cooperation among Member States (MS) in the Mediterranean Sea Region (MED) to implement the Second Cycle of the Marine Directive and in particular to assist them in the preparation of their MSFD reports through the following specific objectives:

- Develop and implement a candidate impact indicator in the Mediterranean Region for D11C1 Criteria.
- Make a joint proposal of a methodology to establish threshold values, list of elements and integration rules to implement the GES decision in reference to D11 in the Mediterranean Region.
- Build an efficient data and information tool to support the implementation of the D11C1 Criteria and the update of the monitoring programmes of Impulsive Noise according the new GES Decision.
- Perform an operational pilot of an impulsive noise impact monitoring programme implemented with the updated Joint register to demonstrate its feasibility.
- Promote Mediterranean Region Coordination by i) boosting current regional cooperation efforts of Barcelona Convention and others and ii) developing new cooperation measures.
- Enhance collaboration among a wide network of stakeholders through the dissemination of the project results, knowledge share and networking.

To achieve its objectives, the project is divided in 3 work packages around 3 priorities and 10 activities whose relationships are shown in Figure 1.

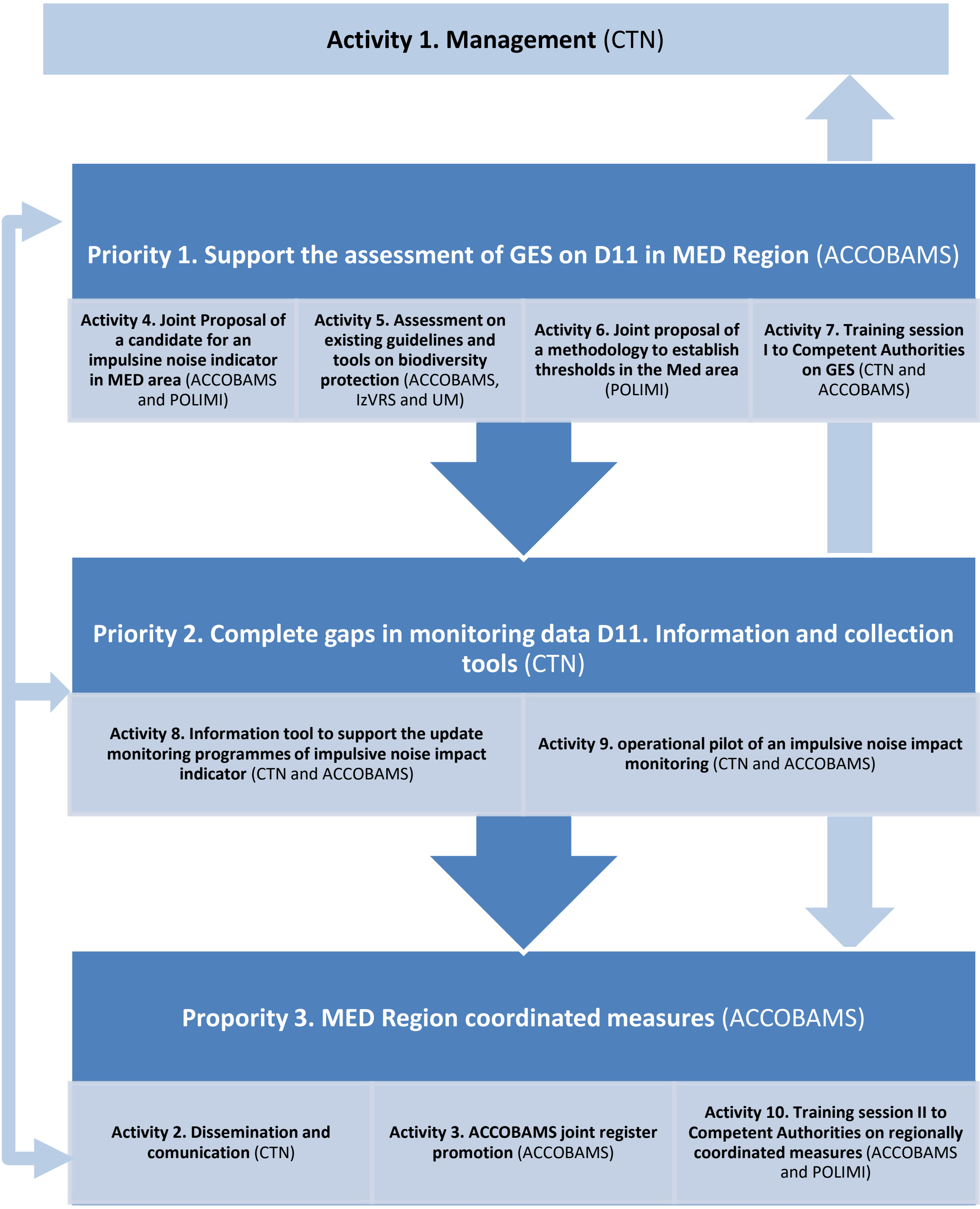

Figure 1. Work Plan Structure

The project is developed by a consortium made up of 11 entities coordinated by CTN and it has a duration of 24 months starting on February 2019.

Activity 6 of QUIETMED2 Project has the following specific objectives:

- Establishment of effective links with Marine Strategy Framework Directive (MSFD) Common Implementation Strategy working group (CIS WG) (mainly TG Noise) to guarantee coordination across the regions or sub-regions and to Member State's national administrations.
- Identify key representative/s in GES working group.
- Identify national and regional barriers and difficulties for the establishment of thresholds, request information during the training session and planned workshop with Competent Authorities (CA)
- Review and assessment of the existing documents from other project and initiatives and CIS Working Groups.
- Analysis of pressures-noise causal and mitigation relationship (through application of new technologies which could decrease the source intensity).
- Identification of requirements to include additional functionalities into the INR-MED.
- Developing a joint proposal methodology to establish thresholds values, lists of elements and integration rules to implement the GES decision concerning the D11 in the Mediterranean Sea Region (MED).
- Development of recommendations about how to implement the methodology to establish thresholds in the MED area.
- Implementation of results to the impulsive noise impact tool in the operational pilot, the functionality on about thresholds.

This document addresses the issue related to the national and regional barriers and difficulties as regards the establishment of threshold values for the Criterion D11C1 (anthropogenic impulsive sound).

2 Analysis of the main criticism identified for the implementation of threshold values for defining achievement of GES

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that the Member States (MS) of the European Union achieve and maintain Good Environmental Status (GES) in European waters by the 2020 (European Commission, 2008). The European Commission produced a set of detailed criteria and methodological standards to help MS implement the MSFD. On the basis of the first cycle assessment, the European Commission has made recommendations in the aim to improve the level of coherency for the second cycle of assessment. For this purpose, the 2008 Directive has been amended (European Commission, 2017) and the 2010 Decision (Decision 2010/477/EU) has been revised (Commission Decision 2017/848/EU). Compared to the previous framework, the new GES Commission Decision 2017 contains a number of criteria and methodological standards for determining GES.

2.1. Critical aspects for the definition and implementation of thresholds

The Commission Decision of 2017 requires the setting of '*threshold values*', thereby contributing to an improved and clearer way to achieve the environmental objectives. Therefore, EU MS should establish '*threshold values'* (TVs) through cooperation at Union level, taking into account regional or sub-regional specificities. TVs are intended to contribute to MS' determination of a set of characteristics for GES and inform their assessment of the extent to which GES is being achieved.

Article 2 of the new Commission Decision 2017 reported the definition of TVs as follows:

'*threshold value' means a value or range of values that allows for an assessment of the quality level achieved for a particular criterion, thereby contributing to the assessment of the extent to which good environmental status is being achieved.*

However, the revision of the first cycle assessment of the MSFD highlighted **disparities among Member States in the scope of GES definition,** which was varying from pressure-based to risk-based and response-based. In this perspective the new Commission Decision (2017, point 6) specifically requests to apply risk-based approach. Accordingly, both TVs and GES definition should be defined at a risk-based level.

The new Commission Decision 2017 requires consistency in the TVs definition with the Union legislation and specificity, reflecting the different biotic and abiotic characteristics of the regions, sub regions and subdivisions of the EU. Accordingly, a critical point is the definition of TVs leading to a GES definition which accounts for subregional particularities (i.e. scales, species or other specific ecosystems) allowing the comparison between marine regions or sub-regions. To date, most of the MS are still far from the TVs definition.

Regulatory requirements in the form of TVs to avoid physical harm in harbour porpoises (*Phocoena phocoena*) from pile driving have been introduced in Germany.

In particular, it was decided that harbour porpoises should not be exposed to noise levels resulting in auditory interference that creates a Temporary Thresholds Shift (TTS). Based on current knowledge, it was considered necessary not to exceed a single sound exposure level (SEL) of 160 dB re 1 µPa2 s and a zero-to-peak sound pressure level (Lpk) of 190 dB re 1 µPa at 750 m distance to the piling location. The German national noise registry contains data about noise measurements during pile driving activities for the development of offshore wind farms in the German Exclusive Economic Zone (EEZ). It provides a substantial basis for assessing influencing factors of the generation and transmission of sound, but also of the effectiveness of noise reduction measures. The current implementation of the TVs is based on percentile statistics, SEL05 exceedance level, which is exceeded in 5% of the time over the total piling period to account for cumulative effects due to multiple blows for driving piles to final penetration depth. The determination of effectivity of the technical noise follows guidance included in the standard DIN SPEC 45653:2017 (available in English).

TG Noise in consultation with the EC and the Working Group Good Environmental Status, (WG GES), was tasked to provide further advice to EU MS on the development of TVs for Descriptor 11. Particularly, according to new Commission Decision 2017 for Descriptor 11 (D11C1; D11C2), TVs development should contribute to ensure that levels of anthropogenic noise do not exceed levels that adversely affect populations of marine animals.

Due to the difficulties in establishing absolute quantitative TVs and the knowledge gaps in marine mammals' response to noise pressures, TG Noise is defining a generic methodology to be used at Union level.

As a result of several workshops focused on setting TVs, TG Noise is proposing a methodology for assessing impulsive noise (REPORT GES_22-2019-18). Two different ways of quantifying the impact of underwater sound has been proposed: a "species-oriented approach", aiming to quantify the sound exposure of a predefined species or hearing group/population; a "habitat approach", aiming to quantify the amount of a predefined habitat that is negatively affected (i.e., where there is potential for disturbance leading to disturbance or displacement). WG GES advised TG Noise not to attempt to choose between these two approaches, but to consider whether a common method would enable both approaches as options. Consequently, TG Noise, further addressing which methods could contribute to quantifying the area potentially affected by impulsive sound sources, and analysing differences in complexity and levels of uncertainty, reached a consensus on a unified stepwise assessment framework/ methodology. The definition of the TVs is discussed in Step 4 ("Establishment of the pressure map"), where MS have a first opportunity to define TVs at the pressure level. "*Such threshold values could be the (maximum) amount of pressure (with the metric still to be defined) that is considered to be the point where good environmental status still occurs. Such a pressure threshold value would still require some insight to the relationship between pressure (exposure to underwater sound) and impact*".

In addition, TVs are reported at Step 7 of the stepwise proposed methodology ("Compute proportion of species or habitat exposed, potentially using an exposure curve or index") at exposure level. It required MS to produce exposure maps possibly through subregional cooperation, where TV could be the (maximum) amount of animal exposure or habitat affected, in time and space (with the metric still to be defined), that is considered to be the point where GES still occurs.

This approach of the TVs definition seems to be more appropriately aligned to the new Commission Decision 2017 than the pressure-based approach. However, in Paragraph 15, L 125/45, of the new Commission Decision 2017 it is mentioned that *Threshold values do not, by themselves, constitute Member States' determinations of good environmental status.* The new Commission Decision (Paragraph 13, L 125/45) specifically requires that TVs *should be set in relation to a reference condition*. A critical point here is the definition of a reference condition (value or range of values) at which impacts from anthropogenic pressures are absent or negligible. In principle, a simple definition for impulsive noise was the one proposed in the TG Noise draft version of the technical report for TVs, as "zero impulsive sound generating activities". However, this exhibits significant difficulties as regards its practical application since, even if impulsive sound generating activities are absent, the background (natural) sound level is known to be affected by the presence of continuous anthropogenic sound (e.g. from maritime traffic) in most EU waters nowadays.
A non-trivial task will be to effectively translate the scientifically derived TVs into policy providing at the same time an operative decision support tool to be implemented by regulatory decision makers in the different MS, taking into account the specificities at the sub-regional scale.

The production of the risk maps will require strong effort in the transnational cooperation among MS. It is important to consider the differences in objectives among MS in the data management, data sharing (i.e. difficulties in the noise sources data sharing) protocols development, resources and expertise in the policy implementation. The standardization of the methodology for the Mediterranean region (to be adaptable to different MS) and the correct interpretation of TVs that will allow a comparison of the defined GES among sub-regions, is a process that requires considerable amount of time. The optimization of this process will be a real challenge of the implementation process.

Others critical points in the applicability of the proposed methodology or in the development of a new methodology, can be identified in: 1) the different levels of knowledge about sensitive species presence, and density among MS of the Mediterranean region; 2) the insufficient level of knowledge about the species-specific response to the exposure to impulsive noise; 3) the uncertainties in predicting the impact at population level. These aspects will be discussed in the following paragraphs.

3 Knowledge gaps identification for the establishment of the thresholds in the Mediterranean context

A major challenge in the implementation of the MSFD is to achieve the necessary scientific knowledge on the elements that define the state of the marine environment. The new Commission Decision (Paragraph 20, L 125/46) requires that *criteria, including threshold values, … should be based on the best available science*.

It is known that marine mammals are particularly sensitive to impulsive noise emission. Although, there is increasing concern regarding the impact of underwater noise on fish and marine invertebrates (Popper et al., 2003, 2004, 2005, 2009), to date most of the research has focused on marine mammals (i.e. mainly cetaceans and pinnipeds, Southall et al., 2007) and a few other vertebrates (i.e. sea turtles) (Klima et al., 1988; McCauley et al., 2002, 2003). Some high energy sound sources have been, in fact, correlated to mortality events of marine mammals, the majority of these involving in the Mediterranean atypical mass strandings of beaked whales (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Evans and Miller, 2003; Freitas, 2004; Martín et al., 2004; Fernández et al., 2005; Parsons et al., 2008; D'Amico et al., 2009).

Although much progress has been made to extend knowledge regarding cetaceans' presence, abundance and the potential impact of underwater noise, substantial knowledge gaps remain. To fulfil MSFD requirements, the actual development of the TVs needs to be done by using all the available scientific evidence. However, the outcome of future studies aimed to fill the existing gaps (occurring especially in the Mediterranean area) will need to be considered. So, the methodology to set TVs should be a "dynamic process" able to integrate new evidences in the implementation process.

3.1 Knowledge gaps in Target/Sensitive species selection at national and sub-regional level

The bathymetry of the Mediterranean Sea is extremely variable, ranging from shallow waters with an extended continental shelf to deep water zones with steep continental slopes located near to the shore. This heterogeneity leads to a wide variety of habitats and therefore to the presence of different communities of species, species richness and biodiversity. The Mediterranean Sea presents a high number of cetaceans' species, so a multi-species habitat approach would be the recommended one for the Mediterranean Region.

The Mediterranean Sea present a high diversity of cetaceans' species, with 11 species present in the Mediterranean region, three of which presenting a limited local distribution (See Deliverable 5.1 *Set of cetacean species representative at national, subregional and regional level in the Mediterranean Region*).

Striped Dolphin (*Stenella coeruleoalba*), Common Bottlenose Dolphin (*Tursiops truncatus*), Short Beaked Common Dolphin (*Delphinus delphis*), Cuvier's Beaked Whale (*Ziphius cavirostris*), Sperm Whale (*Physeter macrocephalus*), Fin Whale (*Balaenoptera physalus*), Risso's Dolphin (*Grampus griseus*) and Long Finned Pilot whale (*Globicephala melas*) are considered as regular in the Mediterranean Sea (Notarbartolo di Sciara, Podestà & Curry, 2016). Though the distribution of the harbour porpoise (*Phocoena phocoena relicta*), and the killer whale (*Orcinus orca*) are known to be limited in the Mediterranean, little is known about the rough-toothed dolphin (*Steno bredanensis*) distribution in this region (Esteban et al., 2016; Fontaine, 2016; Kerem et al., 2016; Palialexis et al., 2018; Frantzis, 2019).

However, most of the knowledge is limited to species (Notarbartolo Di Sciara, Podestà & Curry, 2016): Striped Dolphin (*Stenella coeruleoalba*), Common Bottlenose Dolphin (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus),* Short Beaked Common Dolphin (*Delphinus delphis*), Cuvier's Beaked Whale (*Ziphius cavirostris*), Sperm Whale (*Physeter macrocephalus*) and Fin Whale (*Balaenoptera physalus*).

A review of the existing information at national level has been made by the QUIETMED2 project and it is available as Deliverable 5.1. The heterogeneity in the level of knowledge about species presence among different countries renders the identification of representative target species at national or sub-regional level (Levantine Sea, Aegean Sea, Adriatic Sea, Thyrrenian Sea, Central Mediterranean Sea, etc.) a difficult task. In addition, the Mediterranean sub-regions present a different level of biodiversity in terms of the numbers of cetaceans' species (e.g. in the Adriatic Sea the predominant species is the bottlenose dolphin, see Bearzi et al., 1997, 1999, 2008; Fortuna, C. M., 2007; Genov et al., 2008, 2016) and that causes further difficulties on the implementation of harmonized methodologies towards GES comparison among sub-regions (as requested by new Commission Decision 2017).

The standardization process in selecting the species of interest, constitutes one of the main challenges for the TVs development in the Mediterranean Region and/or for the application of the existing approaches.

At this point, it is important to highlight that an exhaustive picture about the abundance, distribution, and critical habitats (migratory, feeding, mating areas) of all the species at Mediterranean scale, is not available yet.

The use of habitat suitability models, developed on data collected on field, might facilitate the process allowing to estimate the potential habitat of each species of interest in the MED area.

The interest and resources allocated in conducting systematic monitoring programmes to estimate cetaceans' density, differ by MS or by different sub-regions. In addition, if monitoring programs exist, the type of monitoring differs, for example in the type of survey (i.e. visual survey, acoustics survey, ship based or aerial survey, systematic or opportunistic survey) and in the time period covered (i.e. short- and long- term, summer/winter survey), among different areas rendering the comparison of the results inapplicable.

Systematic survey efforts for cetaceans have previously been recognized as heterogeneous across the Mediterranean Sea by Mannocci et al. 2018, who analysed the effort derived from line transect surveys conducted across the Mediterranean Sea (149,225 km from aerial surveys; 153,256 km ship-based), in order to identify gaps in the geographic, temporal, and environmental coverage of survey effort. As reported by Mannocci and colleagues (2018), survey programs have been implemented mostly in summer by European countries in the north-western and central Mediterranean, highlighting the disparity between northern and southern areas of the Mediterranean.

To start filling these gaps, the Parties of ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area) have launched the ACCOBAMS Survey Initiative (ASI) to monitor cetaceans at the entire basin scale during a single set of surveys which aimed at covering the whole region, where allowed. The results of this regional survey may be helpful to fill some of the existing data gaps.

The ASI results may contribute to add useful information to facilitate the species selection or group of species according to their distribution at the larger spatial scale in order to make the TVs and the GES definition comparable among sub-regions. These results will supplement the other data available covering other seasons and local observations collected by long-term research studies.

However, it is also important to consider that the ASI results are not enough to produce abundance estimates for all the species in the different sub-regions considered by the MSFD. Other surveys would be needed to fill data gaps in periods other than summer, in which environmental conditions (and by extension, cetacean distributions) are widely different. Nevertheless, this initiative contributes to improve regional cooperation efforts. In this regard, it will be relevant to consider the output of the UNEP/MAP strategy on underwater noise monitoring, drafted in the framework of the Ecosystem-Approach process (EcAp) by the Joint ACCOBAMS/ ASCOBANS/CMS Working Group on Noise in 2014 (ACCOBAMS, 2014).

Another critical point to consider in defining the target species is the status of the Mediterranean subpopulation. Some populations of cetaceans' species from the Mediterranean which have been investigated genetically are known to be genetically distinct from individuals of the same species found outside the Mediterranean Sea. Some genetically distinct Mediterranean subpopulations are already classified in the IUCN Red List as Endangered, such as the sperm whale and the common dolphin, or Vulnerable, such as the fin whale, the striped dolphin, and Cuvier's beaked whale, while others are Data Deficient (i.e. Risso's dolphin). Furthermore, species not only differ in terms of presence and population conservation status, but also for their level of vulnerability to impulsive noise. This important aspect is considered in the following paragraph.

In addition, it's important to remind that cetaceans are at the top of the marine food chain and therefore, any information about the other trophic levels (i.e. knowledge about cetaceans' preys) might help in better define critical habitats.

Finally, marine soundscape characterization may also provide novel and promising outcomes for the investigation of the functional biodiversity and characterization of marine ecosystems (Harris et al., 2015). Collection and analysis of acoustic signals have been recently proposed as a tool to evaluate the specific features of ecological assemblages and to monitor their acoustic dynamics over space and time. Baseline data will allow to provide a background for future investigations against which to measure the effect of anthropogenic acoustic impact on marine ecosystem.

3.2 Lack of knowledge on Target/Sensitive species' sensitivity to impulsive noise

According to the definition of Descriptor 11 in Comm. Dec. 2017/848, a key issue in the TVs thresholds definition is the understanding of the level at which sound do not adversely affect cetaceans' population. It is well known that underwater noise can potentially cause an impact on cetaceans (Perry C., 1998; Richardson et al., 1995; Würsig & Richardson, 2002; Southall et al., 2007, 2019; Weilgart L. S., 2007; Prideaux G., 2017; Slabbekoorn et al. 2018; Erbe et al. 2019). In particular, several studies conducted in different parts of the world, reported that impulsive noise sources might cause effects on cetaceans. Possible effects of noise on marine animals vary ranging from masking, behavioural disturbance, hearing loss (i.e. temporary threshold shift (TTS) and permanent threshold shift (PTS)), direct physical damage (i.e. the enhanced gas bubbles growth and traumatic brain injury) and death of the receiver (Richardson et al., 1995; Würsig & Richardson, 2002; Gordon et al., 2003; Popper et al., 2003, 2004; Hastings & Popper, 2005; Hildebrand 2005; Janik 2005; Madsen et al., 2006; Thomsen et al., 2006; Nowacek et al., 2007; Southall et al., 2007; Compton et al., 2008). Southall et al. 2007 produced a review of the impacts of underwater noise on marine mammals and proposed criteria for preventing injury based on both peak sound levels and Sound Exposure Level. The authors classified the behavioural impacts that may occur on marine mammals into a response severity scale (based on 9 categories) that vary from very brief interruptions of normal behaviour to very strong responses such as panic reactions that can lead to stranding. The severity of behavioural responses has been considered within several studies using an adaptation of the Southall et al. (2007) response severity scaling.

Species not only differ in term of presence and population status, but also for their level of vulnerability to impulsive noise. According to literature, the most sensitive species to impulsive noise could be represented by deep divers such as sperm whales and beaked whales, (de Quirós et al., 2012, 2019; Kvadsheim et al., 2012; Fahlman et al., 2014) and fin whales (Clark and Gagnon, 2006; Borsani et al., 2008; Castellote et al., 2012; Southall et al., 2019).

The exposure criteria evolve together with new discoveries about the hearing capabilities of the vulnerable species. However, more work should be done to effectively understand the potential exposure to the hazards, which strongly depends by the source of sounds used, the sound pressure produced, the distance from the sounds, the environmental conditions and the vulnerability of the species. The difficulties in assessing the exposure constitute a critical point on the application of a risk-based approach in TVs definition.

It is also important to remark that most of the knowledge on this topic regards non-Mediterranean species. To better understand the level of vulnerability and the potential range of the impact of impulsive noise on Mediterranean cetaceans it is necessary to increase the knowledge about their hearing sensitivity and their bioacoustics characteristics. However, most of the knowledge on Mediterranean cetacean species' hearing thresholds are inferred from studies done in different areas or in captivity.

Studies on hearing sensitivity has been made for bottlenose dolphin (Moore P.W.B., 1997; Brill et al., 2001; Houser et al., 2006; Popov et al. 2009), Risso's dolphin (Nachtigall et al., 2005; Mooney et al., 2006, 2015), pilot whale (Pacini et al., 2010), killer whale (Hall et al., 1972; Szymanski et al., 1999; Branstetter et al., 2017), Cuvier's beaked whale (Cranford et al., 2008; Escobar I., 2016), striped dolphin (Kastelein et al., 2003), common dolphin (Popov et al., 1998), sperm whale (Ridgway et al., 2001) and fin whale (Thompson et al., 1979; Cranford et al. 2015).

The use of passive acoustic devices as tested by the QUIETMED pilot projects (Vella et al. 2018) allowed for the gathering of both noise and bioacoustics features present in the same localities where research was undertaken. Such work should be encouraged throughout the Mediterranean Sea region so as to provide the necessary data to understand marine noise distribution, cetacean presence or absence in association with different noise levels (at any time of the year, winter included) and cetacean bioacoustics characteristics that could guide understanding of the species specific needs and vulnerabilities. Diogou et al. (2019) also report benefits on such year-round acoustic monitoring with sperm whales in Greek waters.

3.3 Difficulties in assessing the extent of the area impacted by impulsive noise

Quantifying the level of anthropogenic pressure on a habitat is a key element for the TVs implementation. Based on the different effects of noise, "theoretical zones" have been proposed (Richardson et al. 1995) considering the distance between source and receiver. This method has been used often in impact assessments, where the zones of noise influences are determined based on noise propagation modelling or sound pressure level measurements.

In order to quantify the impacted habitat by noise source, it is necessary to classify the source, identified areas where the impulsive noise is emitted and characterize the propagation of these sound sources. Noise hotspots have been identified within the ACCOBAMS area (Maglio et al., 2016). Nevertheless, information on the spatial extent of noise-generating activities in the Mediterranean Sea still remains an open issue. Maglio et al. (2016) reported disparities in data availability among different Mediterranean areas (for example, acoustic data may be lacking in southern Mediterranean sub-region). In addition, the rate of occurrence and temporal occurrence of the main noise-producing activities still needs to be quantified for most of the Mediterranean countries.

To quantify the impacted habitat, it is also necessary to perform noise propagation models, to assess the acoustic footprint of the use of one or multiple impulsive noise sources so as to predict their impact on cetaceans' populations or habitats and determine the status of the environment. The implementation of the Impulsive Noise Register (INR), as recommended by TG Noise in the framework of the MSFD process and by ACCOBAMS in the framework of the EcAp initiative (Dekeling et al., 2014; UNEP/MAP, 2015a, 2015b), constitutes a key element for the assessment of the impacted habitat (see Paragraph 4.2).

3.4 Uncertainty in the assessment of the population consequences of the acoustic disturbance for the Target/Sensitive species

Cetaceans' "acoustic habitat" appears nowadays altered by anthropogenic noise having both direct and indirect effects on individuals and population (National Research Council, 2003; Simmonds et al., 2004). Most of the available literature is focused on quantifying the short-term or/and mid-term effect of noise on cetaceans. From a conservation point of view, it is further critical to assess whether anthropogenic marine sound production has a significant effect on marine mammal populations on the long-term, on continual levels, or at critical times or locations that relate to critical life-stages (i.e. feeding grounds, reproductive areas).

Therefore, to evaluate the impact at population level it is important to considered the functional activities that the animals need to perform in spatio-temporal setting (e.g., feeding, migrating, and breeding) in the area where impulsive sounds are emitted (Southall et al., 2007, 2019; Ellison et al., 2012; Miller et al., 2012). The most important effects of noise are those that impact survival, growth, and reproduction (Southall et al., 2007, 2019; Ellison et al., 2012; Miller et al., 2012). In addition, the potential adverse effects can be stratified by season and location. Accordingly, within the TVs development process, it will be crucial to consider the migratory behaviour of the species, the presence of critical habitats (foraging or mating habitat) and the spatial and temporal variation of occurrence. Thus, as indicated earlier, a passive acoustic set-up throughout the Mediterranean taken care by each country could aid to advance on the necessary baseline data leading to best regional monitoring practice.

Several studies reported behavioural responses of cetacean species to impulsive noise. Some of the findings regard species present in the Mediterranean Sea, so results can be adopted to predict Mediterranean species' responses. However, these results clearly indicate that cetacean species are not equally sensitive to human-made noise disturbance.

Responses to impulsive noise ranged from potentially changes in behaviour, e.g., orientation responses of **sperm whales** (Miller et al. 2012) and vocal matching by **pilot whales** (Rendell et al., 1999; DeRuiter et al., 2013; Alves et al., 2014) to behavioural effects. Behavioural effects can be directly linked to fitness, such as avoidance (moving away from the sound source), changes of diving behaviour, change of the vocal activity (i.e. reducing/stopping of echolocation buzzes/clicks).

The behavioural effect can produce reduction or cessation of foraging, changing in the diving behaviour (reducing the ascent rate and increase the ascent duration), or avoidance. In literature the avoidance reaction has been observed in **fin whales** (Clark and Gagnon, 2006; Borsani et al., 2008; Castellote et al., 2012), **killer whales** (Sivle et al. 2012, Miller et al., 2012, 2014; Kuningas et al., 2013), **beaked whales** (Tyack et al., 2011; DeRuiter et al., 2013; Stimpert et al., 2014; Miller et al., 2015), **sperm whales** (Madsen P.T., 2006; Weir C.R., 2008; Miller et al., 2009, 2012; Sivle et al., 2012; Isojunno et al., 2016; Farmer et al., 2018), **long-finned pilot whales** (Sivle et al., 2012; Miller et al., 2012; Antunes et al., 2014; Wensveen et al., 2015), and in **bottlenose dolphins** (Nachtigall et al., 2003, 2004; Mooney et al., 2009; Houser et al., 2013; Finneran et al., 2015; Branstetter et al., 2018).

Kastelein et al. (2006) identified differences in the response of a **striped dolphin** and a **harbour porpoise** to an acoustic alarm. Based on these studies, porpoises strongly react to the sound source by swimming away from it and increasing the respiration rate, while striped dolphins show no reactions.

In the threshold development process for the Mediterranean region, it will also be very important to take into consideration the level of uncertainty in evaluating the effect of a single noise pressure in a context in which cetaceans are exposed to an overall cumulative noise pressures (e.g. from multiple impulsive noise and continuous noise sources) may potentially affecting cetaceans' reactions at population level.

4 Data management barriers at regional/subregional level

4.1 Data availability and confidentiality

Identified difficulties are mainly the legal constraints that national Competent Authorities face concerning the implementation of the MSFD. The implementation requires MS to adopt standardized methodology and collaborate in data gathering and uploading on regional databases (i.e. INR-MED). Data reporting on the Impulsive Noise Register should follow regional instructions related to Descriptor 11 of the MSFD or to the corresponding Ecological Objective 11 of the Ecosystem-Approach process being implemented by the Barcelona Convention. Regional instructions on data reporting should be set at regional level in order to ensure coherency among MS. Therefore, MS should adopt or developed their national instructions following the regional protocol to guarantee the compatibility and the upload of the national information into the regional register and the potential requested reporting.

Major concerns regarding the lack of international coordination and data archiving mechanisms need to be addressed. The differences in MS management of processes for the implementation of regional monitoring and sharing of data (such as, the collection and management of the essential information) appears as the main constraint. A substantially major effort would be required to properly account for all the underwater noise producing activities and their temporal and spatial occurrence.

In addition, the different levels of confidentiality in the management of the information related to human-made activities is an important factor influencing the implementation of the national registers and, consequently, the Impulsive Noise Register for the Mediterranean region (INR-MED). These aspects are obstacles to the effective setting of a threshold/set of thresholds in the short term.

4.2 Implementation of the noise registry

An Impulsive Noise Register for the Mediterranean region (INR-MED) has been developed as one of the main results of the QUIETMED Project. A web-GIS site (http://80.73.144.60/CTN_Geoportal/home/) has been created as a joint tool to allow the collection and sharing of information regarding anthropogenic underwater impulsive sound in support of the implementation of the second cycle of the MSFD in the Mediterranean Sea Region. In order to allow the comparison among other European Regions, the INR-MED has been developed to be compatible with the ICES register for OSPAR (North East Atlantic) and HELCOM (Baltic Sea) Regions. The INR-MED uses a spatial database able to store underwater noise data which are expected to be uploaded by MS, allowing the storage of georeferenced information, and the undertaking of the analysis of the data as the identification of areas most affected by noise generating pressure activities. The implementation of the INR-MED would provide MS a tool for the calculation of the spatial distribution of impulsive sound sources throughout the year (as requested by MSFD) at regional (Mediterranean) or sub-regional level. This assessment could be also used to establish current baseline activity levels.

Major concerns in the registry implementation are:

1. The availability (for MSFD national responsible) of noise data at national level for the development of national registers, that strongly depends on:

   a) the existence of legal obligations to provide information from companies (or entities) that conduct activities that produce (or potentially produce) underwater noise emission.

   b) the coordination among different Ministries, and/or entities involved in the process of permitting activities (industry, environmental agencies, military) and the MSFD implementation.

2. The absence of an obligation for MS of the Mediterranean area to report noise information into the INR-MED.

3. MS should easily submit their data to the INR-MED. The INR-MED can be used as guidance tool for MS to develop the most suitable tool for data collection.

4. The quality and resolution of data uploaded on the INR-MED from MS. As long- term process, the resolution and quality of data should be continuously improved with time and support from data suppliers in order to make the process more and more efficient.

5. It would be advisable to have comparable quality of data (i.e. sound sources typology; metadata associated) by sub-region to guarantee a regional assessment and comparison among different sub-regions.

6. The time required to guarantee a consistency in the level of information available on the INR-MED, for the different Mediterranean sub-regions, aligned with MSFD implementation time period.

It is important to remark that very limited data are currently available on the INR-MED (see also Section 4.1). So, future implementation (data collection) of the INR-MED is advisable for the MSFD implementation at regional level.

5 Recommendations to address the establishment of the thresholds

Main recommendation to address the establishment of the thresholds for the Mediterranean Region are the following:

- Development of a catalogue of risk for the Mediterranean Region. The implementation of a catalogue of risk will help to address the establishment of a methodology to set the thresholds.

- Characterize the sound sources by sub-regions considering their potential effect on vulnerable species (present in area) as function of the acoustic property of the impulsive sounds, the overall durations of emission (hours, days) and repetitiveness of the impulsive sounds' emissions.

- Due to the high cetacean's diversity in the Mediterranean Region, it is recommended to consider a "multi-species approach" in which the presence of the suitable habitat of the species is assessed by sub-regions.

- The vulnerable species presence/habitat should be assessed considering not only their spatial distribution inferred from direct observation, but also assessing the presence of potential suitable habitat (using a precautionary approach) for the species.

6 Conclusions

This Deliverable (6.1) was aiming at addressing the issue related to the national and regional barriers and difficulties for the establishment of threshold values (TVs) for the criterion D11C1 (anthropogenic impulsive sound in water) for the Mediterranean Region.

Critical points in the development of a standardized methodology to establish TVs for the Region (or in the applicability of the proposed methodology) have been highlighted with regards to different aspects such as:

1) the different levels of knowledge about sensitive species presence, and density among MS of the Mediterranean region;

2) the insufficient level of knowledge about the species-specific response to the exposure to impulsive noise;

3) the uncertainties in predicting the impact at population level.

Despite the differences regarding level of knowledge about species sensitivity and response to impulsive noise, it is important to consider the differences among MS in the policy implementation.

The differences in MS management of processes for the implementation of regional monitoring and sharing of data (such as, the collection and management of the essential information) appears as the main constraint.

In this framework, the standardization of the methodology for the Mediterranean region to be adaptable to different MS, and the correct interpretation of the TVs constitute the real challenge.

Essential steps towards the definition of a common methodology are: the implementation of the INR-MED as tool for the calculation of the spatial distribution of impulsive sound sources; the development of a catalogue of risk for the Mediterranean Region; the adoption of a multi-species species approach in which the spatial distribution of the species is assessed, by sub-regions, by considering not only knowledge from direct observation, but also assessing the presence of potential suitable habitat (using a precautionary approach) for the species.

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