JUMP

Joint Action: a stepping-stone for underwater noise monitoring in Portuguese water

Deliverable 2 - Inventory of background information

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SUMÁRIO EXECUTIVO

Considerando que o conhecimento do Descritor 11 nas águas marinhas portuguesas ainda é limitado, foi elaborado um inventário de informação, que visa recolher dados sobre gravações subaquáticas, atividades produtoras de ruído de origem humana e distribuição de espécies sensíveis. Este relatório pretende explicar o processo de desenvolvimento dos inventários e sintetizar o estado da arte das águas portuguesas. As atividades antropogénicas marinhas estão amplamente distribuídas nas águas portuguesas assim como muitas espécies sensíveis, pelo que a regulação do ruído e a monitorização de potenciais impactos nos organismos marinhos deve ser uma prioridade. Em Portugal, a monitorização do ruído subaquático tem sido escassa, e a informação sobre gravações de ruído é limitada, sendo que nem sempre é possível caracterizar as atividades antropogénicas em toda a sua extensão. Estudos futuros devem concentrar-se na monitorização a longo-prazo do ruído subaquático e estudar o impacto do ruído em diferentes grupos taxonómicos. As diretivas que regulam os níveis de ruído subaquático levarão tempo a ser desenvolvidas, e um passo importante para atingir esse objetivo é a promoção da discussão entre *stakeholders* sobre os impactos do ruído no ambiente marinho.

EXECUTIVE SUMARY

Since knowledge on Descriptor 11 in Portuguese marine waters is still limited, an inventory of background information was compiled, in order to gather available data on underwater recordings, noise-producing human activities and distribution of sensitive species. This report intends to explain the development process of the inventories and to summarize the state of the art of Portuguese waters. Marine anthropogenic activities are broadly distributed in Portuguese waters as are many sensitive species, meaning that regulate noise and monitor potential impacts in marine organisms should be a priority. In Portugal, monitorization of underwater noise has been scarce, thus, data on recordings is limited and it is not always possible to characterize anthropogenic activities to their fully extent. Future studies should focus on long-term monitorization of underwater noise and studying the impact of noise on different taxonomic groups. Directives that regulate underwater noise levels will take time to develop, and an important step to achieve that goal is promoting discussion between stakeholders about impacts of noise on marine environment.

1. FRAMEWORK

The Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC) aims to achieve Good Environmental Status (GES) of the EU's marine waters by establishing a framework for community action in the field of marine environmental policy by providing a set of eleven qualitative descriptors which constitute the basis for the assessment and definition of GES. Descriptor 11 relates to the introduction of energy into the marine environment including sound, light and other electromagnetic fields, heat and radioactive energy, which should be at levels that do not adversely affect the marine environment (van der Graaf *et al*., 2012; Zampoukas *et al*., 2014). Two indicators were chosen in Commission Decision 2010/477/EU for describing Descriptor 11: Indicator 11.1.1 on low and mid frequency short-duration impulsive sounds, and Indicator 11.2.1 on continuous low frequency sound (ambient noise) (van der Graaf *et al*., 2012; Zampoukas *et al.*, 2014). Since knowledge on Descriptor 11 in Portuguese marine waters is still limited, the jUMP project aims to implement stepping-stone actions to provide a contribution to the sustainable management of underwater noise by promoting

discussion about its impacts on marine environment and to support the application of the MSFD on Descriptor 11.

Project jUMP is organized in six work packages (WP), of which WP 2 relates to inventory of background information, more specific into: producing a catalogue of existing underwater recordings in the Portuguese marine waters, characterize the type and distribution of noise-producing human activities, and compile information on the distribution of acoustically sensitive species. The following report gives an insight of how the inventories were constructed and the information was compiled and what decisions were made throughout the process.

2. DATA CONTENT AND STRUCTURE

In a first phase, information was collected, in particular, bibliographic references regarding international studies in order to build a more general bibliographic database that would allow to know which anthropogenic sources exist in the marine environment and their impacts on different species. Subsequently, from this database, the inventories shown here were prepared with information referring only to Portugal, which would reflect the state of Portuguese waters, including Madeira and Azores.

2.1 INVENTORY OF UNDERWATER NOISE RECORDINGS

The main objective of this task was to identify and catalogue underwater noise recordings carried out in Portuguese waters. Work was carried out to collect information regarding sea trials that include underwater noise measurements located in Portuguese waters. Next, data about research projects and/or studies with different objectives (e.g. measuring aquatic environmental noise, passive acoustic detection of marine species, characterization of anthropogenic noise) where underwater recordings were conducted was also added to the inventory.

List of underwater recordings sources

The first column concerns **sea trials and/or projects** that involve underwater noise measurements. In the next column, are listed the **members of the projects** and then, a brief **description of the projects** is given for each one of them. Information regarding **date**, **location**, whether or not **noise measurements** were made, and what type of **data** was **collected** is also provided.

Relevant information is recorded in the column **observations** and all the websites, reports and articles accessed regarding the information mentioned are cited last in **references**.

2.2 INVENTORY OF ANTHROPOGENIC ACTIVITIES

This task required to identify the marine activities developed in Portugal that introduce noise on the marine environment and characterize the type of noise and, if possible, the spatial and temporal distribution. From the general database it was possible to list the different marine anthropogenic activities which allow to, then, search and check which noise sources were present in the Portuguese waters.

List of anthropogenic sources

Each line acts as a header - when the user selects by activity or by source, it will appear as if it were a header line in which each activity will correspond to a number of sources, which will then have in that first line the most relevant information about that source – frequency bands, its occurrence in Portugal, if it will be an activity present in the future, and then, the different examples of that source are listed. Thus, the table is constructed from a more general form to a more in-depth one, as the user searches for more specific topics.

The first column concerns the **Marine Strategy Framework Directive (MSFD) Descriptor 11 indicators**: indicator 11.1.1 on low and mid frequency impulsive sounds and indicator 11.2.1 on continuous low frequency sound (ambient noise). All activities and sources were organized based on this first separation – impulsive sound and ambient sound.

Impulsive noise implies a sound comprising one or more pulses, each of short duration, and with long gaps of no significant sound emission between these pulses, and addresses the cumulative impact of activities and the distribution of loud low and mid frequency impulsive sounds, in time and place (Dekeling *et al.*, 2014, van der Graaf *et al.*, 2012, Tasker *et al.*, 2010). Continuous noise focuses on chronic exposure of marine life to low frequency non-impulsive continuous sounds (van der Graaf *et al.*, 2012; Dekeling *et al.*, 2014, Tasker *et al.*, 2010).

The subsequent column refers to **activity,** where the user can choose between different anthropogenic activities such as shipping, marine renewables, offshore construction, use or disposal of explosives, aquaculture and fisheries, dredging, seismic survey (oil and gas exploration) and sonars. Each activity matches to different anthropogenic sources - the list of activities selected was based on literature, an indicative list of activities (table 4 on van der Graaf *et al.*, 2012) and technical reports (Zampoukas *et al.*, 2014, Dekeling *et al.*, 2014, Tasker *et al.*, 2010).

Examples of impulsive sounds are those from offshore construction (such as pile driving), the use of airguns during seismic surveys to inspect subsea oil and gas deposits, various types of sonar sources (boomers, sparkers, scientific echo sounders, military sonars), underwater explosions and acoustic deterrent devices (van der Graaf *et al.*, 2012; Zampoukas *et al.*, 2014, Dekeling *et al.*, 2014, Tasker *et al.*, 2010) - since a difference is made in the use of airguns for oil exploration and boomers and sparkers for shallow mapping sonar search (Götz *et al.*, 2009, van der Graaf *et al.*, 2012, Zampoukas *et al.*, 2014, Dekeling *et al.*, 2014, Tasker *et al.*, 2010), the decision to separate seismic survey using airguns and seismic survey using boomers and sparkers was made. As such, boomers and sparkers can be found in sonar activity as a seismic survey source and airguns can be found in seismic survey (oil and gas exploration) activity.

The main contributor of continuous noise is noise from commercial shipping but other sources like construction noise (e.g., drilling and dredging) or wind farm operation also contribute to ambient noise (Zampoukas *et al.*, 2014, Tasker *et al.*, 2010). Therefore, shipping, marine renewables and dredging appear as continuous noise activities with multiple sources.

Shipping activity was divided in 3 categories according with Götz *et al*. (2009) in small leisure craft and boats, medium size ships and large vessels with shipping. The size of the ship is an important feature,

since it can define whether a particular ship can enter a particular port. As the size of ships, in particular cargo ships, increases, so that it can transport more goods, it becomes equally important to widen the navigation channels of ports so that large ships can receive them. Thus, a division base on the size of the vessels was chosen for the different categories. In addition, it is important to mention that the numbers of types of vessels indicated in the table are only estimates, and serve only as an example to demonstrate that there is a strong pressure from vessels in Portugal. Furthermore, a complex network of commercial shipping routes crosses the maritime areas under national jurisdiction of Portugal (Silveira et al., 2011) and, as such, international ships are also an important variable when considering shipping in Portuguese waters – however, international vessels were not taken in account in the numbers presented in the table.

The column that mentions **anthropogenic sources** consequently enumerates different sources associated with different activities: small leisure craft and boats, medium size ships and large vessels with shipping; offshore wind farms (during operation) and marine renewable energy (MRE) devices (wave energy converters [WECs] and tidal, river, and ocean current turbines) (during operation) with marine renewables; pile-driving with offshore construction; underwater explosions with use or disposal of explosives; low-level acoustic deterrent devices (ADDs, e.g. pingers) and high-level acoustic harassment devices (AHDs, e.g. seal scarers) with aquaculture and fisheries; maintenance dredging in fishing and recreational ports, emergency dredging, maintenance dredging in commercial ports, channel deepening (to accommodate larger ships) with dredging; seismic surveys using airguns with seismic surveys (oil and gas exploration); and seismic surveys using boomers and sparkers, commercial sonars (multibeam echosounders, scientific echosounders, fish finders), military sonar (low-frequency (LFA), mid-frequency and high-frequency sonars) with sonars.

From then on, a research was done in order to understand if the different anthropogenic sources were **present in Portugal** and, if so, in what regions. However, it is equally relevant to know if a source and/or activity are **considered in the Portuguese MSP** (marine spatial planning), because it gives us a chance to anticipate whether that specific source/activity will be more significant in both spatial and temporal occurrence.

The planning of the national maritime space has as its objective the management of human activities that occur in the Portuguese sea, both in spatial and temporal terms. The national maritime spatial planning will be done through the preparation of the Situation Plan (PSOEM)[1] which is an instrument for the national maritime space management developed jointly by the DGRM, the Central Government, DROTA (Regional Directorate for Territorial Ordering and Environment – Regional Secretariat of the Environment and Natural Resources (SRA) of the Madeira Government) and DRAM (Azores Regional Directorate of Maritime Affairs). This plan is also the instrument that allows the attribution of the Title of Privative Use of the National Maritime Space (TUPEM) - the right to private use of the national maritime space is granted by concession, license or authorization. The marine areas where activities subject to TUPEM can be located are classified into two types: potential areas for the establishment of a specific use/activity and exclusion areas for certain uses or activities. Potential areas are those considered appropriate for the potential installation of certain uses/activities subject to TUPEM and which require specific marine areas for their occurrence (e.g. aquaculture). Some uses or activities may occur generically in the ocean and it does not make sense to define potential areas - in this case, exclusion areas are defined. Some uses and activities are not subject to spatialization, that

[1]https://www.psoem.pt/

is, they do not have mapping associated with the potential areas for their installation - this happens for the uses and activities that can generally occur in the entire maritime space (e.g. fishing when associated with infrastructure, marine biotechnology, deep sea mining, etc). For this reason, for some anthropogenic sources we cannot define regions of special concern, as that information is only available for some sources.

Other national marine management programs are: the coastal shoreline programs (POC)[2] that cover a strip along the terrestrial coast and a maritime zone (up to 30m depth), including areas under port jurisdiction and are defined in North, Centre, Tagus, Alentejo and Algarve; the National Strategy for the Sea 2013-2020[3] that aims to the development of activities and sectors such as port infrastructure and maritime transport, naval construction and maintenance, renewable energies (wave energies and offshore wind resources), coastal defence maritime works, cables and submarine pipelines, research and exploration of oil and gas; and the Multiannual Port Dredging Plan for 2018-2022 that covers 20 fishing and recreational ports in mainland Portugal and comprises proposals concerning the maintenance of approach channels and basins (dredging areas and depths) (LNEC, 2017). All these reports were consulted and relevant information is registered.

Finally, in order to perceive the amount of pressure that each anthropogenic source puts on the environment, a list of all **examples in Portuguese waters** was recorded and, when possible, the location and duration too. It was important to show, not only if the source is present in Portugal but also, if there's any kind of pattern of spatial and/or time distribution that could translate into a more relevant and prevailing anthropogenic source in Portuguese waters.

Relevant information regarding the anthropogenic activity and/or source is stated in the column **observations**. All websites, reports and articles consulted regarding the information placed in the table are registered in the column **references**.

2.3 INVENTORY OF SENSITIVE SPECIES OCCURRENCE AND DISTRIBUTION

Many aquatic animals rely on sound to survive, so this task aims to list important sensitive species occurring in Portuguese waters and, whenever possible, to characterize its occurrence and distribution. The bibliographic database documented studies regarding the impact of anthropogenic sources and a wide variety of species, subsequently, it was verified whether or not each of these species was present in Portuguese waters, and their distribution and occurrence were registered, if possible.

List of sensitive species

The first column concerns the **class** of the species, so that more comprehensive research can be done.

The following three columns, **potential disturbing anthropogenic source**, **potential impact/change** and **sensitive species** are directly associated with the scientific articles consulted – which resulted from a previous research and information compilation.

The column **occurrence in Portugal** simple states whether or not the species is present in Portugal (yes or no), and in the cases were its present it can be seen where the species occurs in **distribution in Portugal**.

[2]https://www.apambiente.pt/index.php?ref=16&subref=7&sub2ref=10&sub3ref=94
[3]https://www.dgpm.mm.gov.pt/enm

The **occurrence category** concerns the species population density (regular, occasional, rare, present or absent), the permanency of populations concerning migratory species (wintering) and information on the status of residency of a species (residency status, native). This category was compiled with information that could have the most similarities with the INSPIRE directive guidelines for the species distribution theme (INSPIRE Thematic Working Group Species Distribution, 2013), however some changes were made, as the directive separates some concepts and, in this category, we decided to put them together.

In the event that the sensitive species does not occur in Portugal, an example of species of the same taxonomic family is given as an alternative – **species of the same family occurring in Portugal**- it was considered species of the same taxonomic family because the genus is still a very close connection yet order is quite distant from the sensitive species. This species is referred to as an alternative/probable sensitive species because it's not the one mentioned in the article and so, there is no scientific evidence to prove that the alternative species is sensitive. However, because it is from the same taxonomic family as the sensitive species it shares some similarities which could mean that it could be considered a potential sensitive species to noise as well.

If, on the other hand, the sensitive species does not occur in Portugal and neither does a species of the same family, then, the species is removed from the list (there were 128 species listed prior to selection as opposed to 106).

The **conservation status** of the sensitive species or species of the same family was also considered and that information was obtained from the IUCN Red List of Threatened Species (https://www.iucnredlist.org/) when that information was not available, no data available was noted. Also, the conservation status in Portugal, as reported by the Red Book of Vertebrates (Cabral *et al.*, 2005), was added because species can have a different status according with their regional distribution and it was considered important since this project focus on Portuguese waters.

Relevant information concerning the sensitive species is mentioned in the column **observations**.

All **references** consulted regarding the information placed in the table are recorded in the last column: the article that demonstrates sensitivity of the species (including potential source and impact); websites, reports and articles showing whether the species occurs in Portugal and its distribution pattern and information regarding the alternative species and conservation status.

3. CONCLUSIONS

3.1 STATE OF THE ART OF PORTUGUESE WATERS

Monitorization of underwater noise in Portuguese waters has been, essentially, sporadically made, although there have been records throughout the years, many of those were limited, both in range and duration. Passive acoustic monitoring (PAM) is a common tool used to detect and process underwater sound, and many PAM devices and other acoustic receptors have been deployed in the ocean to study underwater noise and its impacts. Projects that implement this technology can provide useful data concerning noise levels, and projects like jUMP can contribute to the implementation of D11 by providing the first approach to a systematic assessment of underwater noise levels based on marine underwater noise snapshots. Furthermore, oceanographic data monitoring projects may allow to collect acoustic data by using specialized equipment for this purpose. In addition, scientific studies also provide data on underwater noise when underwater recordings are made, however these are usually done with a specific purpose and limited in scope. In general, underwater noise monitoring in Portuguese waters has been short-term and recordings are not sufficient to establish baseline noise levels.

Marine anthropogenic activities are broadly present in Portuguese waters, as it can be seen in the inventory of anthropogenic activities: seismic surveys, dredging (both channel/port maintenance and navigation channels deepening works), use of civilian and military sonars (for detection, location and classification of various underwater targets), pile driving and underwater explosions (associated with maritime construction works), marine renewable energies (whether by wave energy or offshore wind farms), and acoustic alarms (used in fishing nets to avoid accidental capture of cetaceans).

Regarding impulsive noises, from 2012 to 2018, geophysical campaigns with different purposes were identified: associated with the exploitation of mineral resources (using airguns), in the context of geological cartography studies; and with bathymetry data acquisition (DQEM, 2020b). Although some hydrocarbon prospecting and research work has been carried out over the years in Portuguese sedimentary basins, there is still no oil production/exploration in Portugal, as there was no discovery with economic viability that would allow the country to consider the transition to the following stages of development (ENMC, 2017, DQEM, 2020b). All oil and gas operations were therefore carried out within the scope of the prospecting and research phase, in which the activity developed has been very intermittent, characterized by short-term operations (one week to three months) and located in space (ENMC, 2017). Another source of underwater noise important to consider, referring to continuous noise, is marine traffic, which is the predominant noise source in Portugal. Due to the geographic position and port system whose handled cargo has been growing annually, Portugal is an important logistics hub in Europe, and an increase in naval industry is to be expected. Consequently, it is likely that noise from marine traffic will increase, as well as, most of these activities are expected to continue to occur, which makes it important to develop regulations in order to decrease noise emissions and monitor potential impacts in sensitive species in Portuguese waters.

Sensitive marine life, from invertebrates to marine mammals, use sound for survival (in important activities and/or for acoustic cues). Moreover, different species have different hearing sensitivities, and species that use sound to communicate are also acoustically sensitive species. Thus, sensitive species are susceptible to noise effects in a broadband matter and can sustain various impacts. Species

of various classes are present in Portuguese waters, such as bivalves, cephalopods, cnidarians, crustaceans, echinoderms, fish, marine mammals, sea turtles and sea birds. Some examples are resident species like the monk seal (in Madeira), the sperm whale (in Azores), the long-snouted seahorse (in Ria Formosa, Olhão) and the bottlenose dolphin (resident population in Sado estuary, Setubal). Other species include, the octopus, the cuttlefish, the snapping shrimp, the bluefin tuna, the lusitanian toadfish, the scalloped hammerhead shark, the great cormorant, the northern gannet, the common dolphin (species of cetacean most abundant in national waters), the fin whale and the loggerhead sea turtle. Furthermore, the Azores archipelago is an important migratory habitat and feeding area for several species of bearded whales (e.g., blue whale and fin whale) (Romagosa et al., 2017), and, as such, it is of great interest to develop monitoring projects of underwater noise in Azorean waters (DQEM, 2020d). Considering that so many sensitive species are present in Portuguese waters, it is important to regulate noise in order to avoid impact in these species.

3.1.1 MSFD in Portugal

In Portugal, for the purposes of implementing the MSFD, and given that the maritime waters under jurisdiction of Portugal fall within the Atlantic Northeast region and two other sub-regions (the Bay of Biscay and the Iberian Coast and Macaronesia), the elaboration of four marine strategies were determined: subdivision of the Mainland, subdivision of the Extended Continental Shelf (ECS), subdivision of the Azores, and subdivision of Madeira (DQEM, 2020a).

The initial assessment carried out on the subdivision of the Mainland concluded that the information available was very scarce, both in terms of acoustic monitoring (continuous noise) and in the recording of sources of anthropogenic noise (impulsive noise), making it impossible to carry out a characterization and assessment of the state of the marine waters for the descriptor 11 (DQEM, 2020b). For impulsive (or short duration) noise, data collected show that the spatial and temporal overlap between noise and cetacean events, if any, did not exceed an area of 2% of the total subdivision (DQEM, 2020b). Although an increase in anthropogenic activities is expected in the coming years, the marine strategy states that it is unlikely that there will be significant adverse effects on marine animal populations, provided that appropriate measures continue to be adopted to manage these activities (DQEM, 2020b). It was not possible to model the low-frequency noise levels in the continent subdivision in order to evaluate the continuous noise indicator (DQEM, 2020b).

Regarding the subdivision of the Extended Continental Shelf (ECS), there is no knowledge about activities that produce short-duration anthropogenic noise (impulsive noise), nor is there a sufficiently robust model to model low frequency noise levels (continuous noise) in the ECS subdivision in order to assess the descriptor 11. However, it is considered that the influence of sources of acoustic energy, essentially originated by maritime traffic, on the ECS's benthic ecosystems, given the high depths to which they are found, is small or even non-existent (DQEM, 2020c).

In the first assessment of the descriptor 11 for the subdivision of the Azores, it was described that the existing information on marine noise was very limited, making it impossible to assess the GES (DQEM, 2020d). In the Azores region, impulsive noise sources are considered to be sporadic and punctual, resulting from port works, seismic surveys and other studies (DQEM, 2020d). Maritime traffic was considered as the main source of continuous low frequency noise, despite the fact there are no

monitoring programs for this type of noise (DQEM, 2020d). Although progress has been made in gathering information by implementing new research projects in the Azores subdivision, it is considered that the lack of information and monitorization of anthropogenic impulsive and continuous noise has made it impossible to characterize underwater noise pollution in the region and assess the impact on different marine organisms (DQEM, 2020d).

Currently, it is still not possible to characterize and assess the status of marine waters for the descriptor 11 for the subdivision of Madeira (DQEM, 2020e). Regarding underwater noise, there is no platform for recording anthropogenic activities that generate noise, so given the available information, there are no results for any of the corresponding criteria (DQEM, 2020e).

Understanding the effects of noise, both at the individual and population level, remains the main challenge, thus environmental targets for the descriptor 11 in Portugal have been established (DQEM, 2020b, DQEM, 2020c, DQEM, 2020d, DQEM, 2020e). Additionally, to address the lack of existing knowledge and monitoring programs for underwater noise and risk assessment for acoustically sensitive species, different projects have been implemented in the Azores and Madeira subdivisions (DQEM, 2020d, DQEM, 2020e).

3.2 LIMITATIONS

On the subject of the development of the inventories, the lack of data about underwater noise in Portuguese waters made it difficult to get more results. In Portugal, monitoring or even regulation of the introduction of noise into the marine environment has been scarce, so data on recordings of underwater noise is limited. Consequently, it is not always possible to characterize anthropogenic activities according with their spatial and temporal distribution. Furthermore, the acoustic data available were collected punctually, within the scope of environmental impact assessments or local characterization of the acoustic environment (e.g., acoustic campaigns and/or scientific studies) which do not allow a quantitative assessment of the descriptor 11 in Portugal (DQEM, 2020b). As for sensitive species that occur in Portugal, information about their occurrence and distribution is not always available due to the lack of studies on this topic. Yet, it is important to mention that efforts have been made in order to know more about anthropogenic noise and its impact on marine life in Portuguese waters.

On a broader scope, additional scientific and technical knowledge is still required to support the development of criteria related to descriptor 11 in the MSFD, including in relation to impacts on marine life, relevant noise sources and frequency levels and, as such, measurement of underwater noise has been identified as a priority (van der Graaf *et al*., 2012; Zampoukas *et al*., 2014).

The lack of impact studies on different species, especially on fish and invertebrates, makes it difficult to assess the impact of noise on marine organisms. It is important to understand whether the effects between different taxonomic groups are similar or whether different metrics and response characteristics are needed to study the effects in different groups (Hawkins *et al*., 2015). Also, there is still a gap in information on hearing abilities (audiograms) of many acoustically active species which are suspected of being sensitive to anthropogenic noise (Williams *et al*., 2015).

Noise levels measurements are sometimes difficult to compare because a wide range of instruments and different methodologies and/or acoustic metrics are used to analyze underwater sounds, and

results can take on different meanings for each different application (Robinson *et al*., 2014, Hawkins *et al*., 2015). Thus, a consensus on the adoption of relevant and acceptable metrics that describe sounds appropriately and enable comparison of the effects of sounds on different species is needed (Hawkins *et al*., 2015).

3.3 RECOMMENDATIONS AND FUTURE STUDIES

Currently, there is no baseline data for underwater noise. Future studies should focus on long-term monitorization of underwater noise, and both the cumulative and synergetic effects of different anthropogenic sources should be considered. Studies concerning the effects of noise on marine organisms should integrate physiological and behavioral responses, as well as, be more inclusive regarding different taxa. Filling these gaps will allow a more comprehensive understanding of cause-effect relationships and long-term underwater noise consequences.

Regulations and guidelines that impose restrictions on underwater noise and minimize impact on animals, require communication between all stakeholders (science, industry, regulators) and should be updated regularly and include the latest scientific data. Furthermore, agencies should work on re-examining concepts and definitions and agreed standards using appropriate acoustic metrics to measure underwater noise, which will facilitate the assessment of noise on international level. International collaboration and exchange of information becomes relevant when we consider that many migratory species cross the ocean and are exposed to different noise levels across their journey. Also, sound can travel over great distances and the ocean has no barriers, which means that underwater noise in a specific location could include sources that are beyond national borders.

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5. GLOSSARY

'Good Environmental Status' means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations (MSFD Art. 3(5), abbreviated).

Basin or sedimentary basin[1,2] –is a geological formation, resulting from a depression in the crust of the Earth formed by plate tectonic activity in which sediments accumulate. A typical sedimentary basin is composed of alternating layers of sedimentary rocks. If rich hydrocarbon source rocks occur in combination with appropriate depth and duration of burial, then a petroleum system can develop within the basin. Some of these geologic formations can store and produce significant quantities of petroleum. Sometimes we refer to basins in terms of their geographic location e.g., Algarve Basin.

Cumulative effects[3] - results from the repetition of time and the accumulation of effects from a single type of source

Synergistic effects[3] - results from the accumulation of effects of a series of different types of stressors

[1]https://www.glossary.oilfield.slb.com/en/Terms/b/basin.aspx
[2]https://www.geoexpro.com/articles/2019/05/geological-basin-classification
[3]Weilgart L.S. (2007) The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology, 85(11), 1091-1116.