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Mini Review

Navigating the Marine Strategy Framework Directive D11: Updates on Threshold Values and Future Perspectives

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Abstract

The Marine Strategy Framework Directive (MSFD), enacted by the European Union in 2008, seeks to achieve a Good Environmental Status (GES) for European seas through 11 qualitative descriptors. This paper specifically examines Descriptor 11 (D11), which focuses on the impact of anthropogenic noise on marine ecosystems. Despite significant advancements and extensive work done by expert groups and researchers to establish methodologies for assessing this issue, critical gaps remain, such as the effects of anthropogenic noise on many marine species, including cetaceans. As the second MSFD cycle concludes, this paper emphasizes the need for further research on other forms of energy, such as electromagnetic fields, and advocates for standardized approaches, including a unified Level of Onset of Adverse Biological Effects (LOBE) for species and habitat.

Introduction

The Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD), adopted in 2008, is a key piece of European Union legislation aimed at the integrated and sustainable management of European seas and oceans [1]. Its main goal is to ensure that all human activities affecting the seas are carried out sustainably, promoting the health and Good Environmental Status (GES) of marine ecosystems. This directive establishes a framework for cooperation among EU member states and sets clear objectives to achieve GES in all European marine waters by 2020. It also requires member countries to develop marine strategies for their national waters, identifying environmental pressures and impacts and establishing measures to effectively address them [1].

In 2008, the MSFD introduced 11 environmental descriptors to assess the environmental status of European marine waters. These descriptors provide a solid scientific basis for monitoring and measuring progress toward achieving GES. The descriptions are presented in Table 1.

The MSFD operates in six-year cycles, during which various actions are required: establishing monitoring programs, assessing environmental status, and defining and implementing programs of measures following an ecosystem-based approach (e.g., using natural resources while maintaining the balance of the ecosystem). Despite the efforts made, the implementation of the MSFD faces challenges, especially regarding the clarity of certain measures and provisions, such as the geographical scope (regional or national) for achieving GES and the definition of threshold values [1].

The directive requires that threshold values be designed in a way that "ensures coherence and comparability between marine regions or subregions in the assessments of the degree of achievement of the GES." For each qualitative descriptor, it is necessary to define the criteria, including the relevant

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Table 1: Qualitative descriptors for determining good environmental status based on the MSFD [1].

Number	Descriptor	Criteria
D1	Biodiversity and habitats	The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic, and climatic conditions.
D2	Non-indigenous species	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
D3	Fish and shellfish populations	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
D4	Marine food webs	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
D5	Eutrophication	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms, and oxygen deficiency in bottom waters.
D6	Sea-floor integrity	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
D7	Alteration of hydrographic conditions	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
D8	Concentrations of contaminants	Concentrations of contaminants are at levels to not give rise to pollution effects.
D9	Contaminants in fish and seafood	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
D10	Marine litter	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
D11	Introduction of energy	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

elements, and when appropriate, the threshold values to be used. These threshold values enable the assessment of the quality level achieved with a given criterion [2].

D11-Introduction of energy in the marine ecosystem

Many marine species, especially cetaceans, rely on sound for critical functions such as feeding and reproduction [3-5]. Moreover, sound also plays a key role in avoiding predators, making it the primary sensory mechanism for survival [6,7]. Unlike vision, which is only effective within the first few hundred meters below the ocean's surface, sound can travel vast distances, often spanning thousands of kilometers, allowing mysticetes (baleen whales) to communicate across the Atlantic [8].

Given this reliance, anthropogenic noise can have a profound impact on the marine environment. Depending on its intensity, human-made sounds can travel long distances, potentially disrupting cetaceans' ability to detect prey or predators, follow migratory routes, and communicate with one another. In extreme cases, this disruption may even lead to death [9-11].

To address these concerns, the MSFD includes provisions related to anthropogenic noise under D11. Descriptor 11 sets out two specific criteria: D11-C1 for anthropogenic impulsive noise and D11-C2 for anthropogenic continuous low-frequency noise [1]. D11-C1 encompasses three types of noise: multiple impulsive sound events (e.g., pile driving and airguns), single impulsive events (e.g., explosions), and continuous non-pulse events (e.g., sonars). D11-C2 focuses on continuous low-frequency sounds, such as those produced by marine traffic [12]. For both criteria, the MSFD considers the spatial distribution, temporal extent, and levels of anthropogenic noise.

Technical Group on underwater Noise (TG-Noise)

More recently, the expert group in the European Commission, the Technical Group on Underwater Noise (TG-Noise), has worked extensively to establish thresholds for D11. Indeed, they have been the ones establishing the threshold in the last Commission Decision [13]. The aim of the group is not only to establish the threshold but also to create a generic methodology for assessing the effects of anthropogenic noise on the marine environment. In that case, the threshold can be established in other scenarios that are not the ones exemplified in the report (Table 2).

To achieve the GES, it is crucial to consider regional specificities, including both biotic and abiotic characteristics. To address these regional or subregional nuances, the TG-Noise recommends that EU Member States (MS) establish Level of Onset of Adverse Biologcal Effects (LOBE) values at the regional level, guided by expert advice. LOBE refers to the sound level above which adverse biological effects on an indicator species are expected. These effects can impact the comfort, survival, and vital functions of individual animals. Nevertheless, TG-Noise has not specified the disturbance and rather has left it to the MS to establish it [12,14].

Ideally, LOBE should never be exceeded, but in practice, it may be. It is important to understand that occasional exceedances of LOBE in certain parts of the assessment or habitat area do not automatically mean that the GES is compromised. For status to be considered tolerable, exceedances of LOBE should be infrequent and limited to relatively small areas. Moreover, LOBE should be specified in appropriate metrics, including sound pressure and duration of the acoustic event, e.g. it might be a sound pressure level delimiting the zones of no (or low)

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Table 2: Metodology for assessing a GES for D11 [12,14].

Steps	The practical implementation for D11-C1	The practical implementation for D11-C2
1	Definition of the Management Area	Define indicator species and their habitats
2	Determination of the assessment area/ habitat of the indicator species	Define the level of LOBE
3	Evaluation of completeness and quality of the data	Determine time periods for assessment
4	Consideration of LOBE	Assess the acoustic status by monitoring
5	Selection of a propagation model to estimate sound pressure fields, effect ranges, or scientifically justified effect ranges	Assess the acoustic status by monitoring
6	Determination of the temporal and spatial noise pressure	Establish the reference condition
7	Calculation of exposure using assessment/habitat area and noise pressure and determining the exposed habitat (% area and time exposed)	Establish the current condition
8	Calculation of exposure using assessment/habitat area and noise pressure and determining the exposed habitat (% area and time exposed)	Determine the status of the habitats
9		Assess the status of the Marine Reporting Unit as being GES or not GES

effect and adverse effect. Additionally, any exceedance of LOBE should not result in the killing or injuring of indicator species [15]. If such harm occurs, it indicates an extreme event that must be addressed, as it falls outside the tolerable limits [12,14].

Commission notice on the threshold values set under the marine strategy framework directive 2008/56/EC and commission decision (EU) 2017/848 (C/2024/2078)

In March 2024, the European Commission published a communication regarding the threshold values of the MSFD. This communication aims to clarify issues related to the legal status and the use of threshold values to achieve the GES in marine environments, as well as to provide standardized specifications and methods for monitoring and assessment [13]. The publication of this communication coincides with the end of the second cycle of the MSFD, therefore by the end of 2024, it is expected to have the latest update regarding its thresholds.

In the communication, some threshold values have been established; however, not for all descriptors. Moreover, the threshold values are not exact quantitative indices but are rather general and not species-specific, which would be ideal for achieving the GES objectives. Specifically for D11, the values change depending on if it is D11-C1 or D11-C2.

For D11-C1 it says that for short-term exposure (1 day), the maximum proportion of an assessment/habitat area used by a species of interest that is accepted to be exposed to impulsive noise levels higher than the LOBE is 20 % or lower. On the other hand, for long-term exposure (1 year) the maximum proportion (considering the average exposure) used by a species of interest is 10% or lower. Regarding D11-C2, 20% of the habitat of the target species with noise levels above LOBE must not be exceeded for any month of the assessment year. For this last one, these values are used as they are in concordance with the conservation objective of conserving 80% of carrying capacity/habitat size [13].

On the other hand, those still pending definition at the Union level include marine litter, both in the surface layer and on the seabed; micro-litter in the coastal strip, surface, and sediment; and those applicable to the level of adverse effects on seabed habitats. The recent Commission report highlights the importance that, once these thresholds are decided, they are respected by all member states, regardless of other regional values [13].

Discussion

The Commission Notice [13] can create doubts among environmental consultancies aiming to conduct environmental impact studies. What is "LOBE"? Are they referring to changes in the migration route, temporary changes in their feedings, or in their acoustic sensitivity?

Nowadays, the U.S. National Marine Fisheries Service uses the "120 dB criterion" as a received level above which potentially harmful noise effects could occur, and therefore, attempted to limit animal exposure to levels below this threshold for continuos noise. The "120 dB criterion" was based on two sets of field studies [16,17] in which gray whales and bowhead whales consistently showed avoidance of continuous industrial noise at average received levels of 120 dB re 1 µPa Sound Preassure Level (SPL). More recently, Southall and colleagues have been working extensively to define noise exposure curves for cetaceans based on similarities in their hearing for Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS) [18,19].

TTS refers to a temporary and recoverable reduction in acoustic sensitivity, usually resolving within minutes or hours. In contrast, PTS represents a permanent reduction in hearing sensitivity [15]. However, repeated temporary damage to the auditory system can accumulate over time, potentially leading to permanent impairment, making it a concern that should not be neglected. These curves are highly valuable as they shed light on impacts that otherwise could not be quantified, but they are not perfect. For species such as sirenians (dugongs and manatees) and mysticetes (baleen whales), the curves were established without direct empirical data due to the difficulties in studying them, and for the rest of the species few data was used, most of them in captivity [18].

Regarding the impact of anthropogenic impulsive noise on cetaceans, significant efforts have been made due to the severe nature of the effects and the relative ease of conducting before-after-control-impact (BACI) studies [20,21]. Nevertheless, for D11-C2 is more difficult to study their negative effects on cetaceans. Continuous noise, such as that produced by maritime traffic, is difficult to control. Continuous noise is always present. Exceptional events that have reduced maritime traffic have highlighted the negative impacts of Descriptor

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11-C2. Following the September 11, 2001 attacks in Canada, North Atlantic right whales showed a significant decrease in fecal hormone levels compared to usual traffic conditions [22]. More recently, studies conducted in the Canary Islands during the COVID-19 pandemic recorded dolphin whistles that, under normal traffic conditions, could have not been detected [23]. Therefore, an effort to understand how marine traffic affects the distribution of cetaceans should be taken into consideration, even with the difficulties of carrying them out.

Conclusion

Now that the second cycle Of the MSFD is ending, we are awaiting updates on the new components and, if possible, information for the descriptors that are still lacking. In the case of underwater noise, more experiments are needed, especially with sirenians and mysticetes in their natural habitats, to understand their real effects on the D11. Only then can TTS threshold lines be established based on empirical values. In addition, the definition of LOBE is still obscure. A standardized approach to establishing the LOBE should be implemented, beginning with cetaceans. For maximum precision, this should be tailored to each MS and specific species.

Moreover, it is worth noting that Descriptor 11 refers to the energy emitted into the environment. This means that much research is still needed to understand how other types of energy, such as electromagnetic fields or artificial light, affect marine species. We hope that in the coming cycles, threshold values can be established for the missing descriptors and that projects will continue to be funded to more precisely determine the effects of energy in the marine environment, especially now that countries like Spain plan to implement floating offshore wind farms which impact on the marine ecosystem still obscure [24].

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