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ASSESSING THE BACKGROUND NOISE ON THE NORTH-WESTERN BLACK SEA SHELF

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Abstract. The Black Sea is one of the world's unique seas as a semi-enclosed sea, and its ports are the eastern maritime frontier of the European Union. This paper aims to complement the work as is required in the Marine Strategy Framework Directive of the European Union (MSFD) Descriptor 11 noise-related criteria for anthropogenic impulsive sound in water (D11C1) and anthropogenic continuous low-frequency sound in water (D11C2). Statistically, the Romanian ports handled about 14% of cargo traffic in Central and Eastern Europe from 2015 – to 2019. Main routes for vessel traffic in the territorial sea, the contiguous zone, and Romania's EEZ can be divided into three main areas: high vessel traffic intensity, medium vessel traffic intensity, and low vessel traffic intensity (D11C2). Furthermore, for anthropogenic continuous low-frequency sound, the variability of underwater noise has been investigated from the in-situ noise data (using the Cetacean Research and Brüel & Kjær Hydrophone systems). Current background noise levels were established for the 63Hz and 125Hz (based on frequency bands where noise from shipping is most likely to dominate over other sources), and we assessed the noise hydrospatial coverage for the summer (2019 and 2020) and spring (2022) recordings period in the Romanian Black Sea waters.

Keywords: underwater noise, Marine Strategy Framework Directive, background noise assessment, Black Sea

INTRODUCTION. In Romania, the MSFD is transposed into the national legislation by the Regulation on the Protection of the Environment in Marine Waters, through the Emergency Governmental Ordinance 71/2010 and adopted by Law 6/2011 with later changes in law 205/2013. Until the risen concern of the underwater noise impact on the marine ecosystem and *Marine Strategy Framework Directive European (MSFD)* implementation, the topic was covered in the Western Black sea shelf by the Romanian Navy for military purposes. Our interest region still lacks information on background noise data to comply with MSFD requirements, and modelling tools should be developed for the NWBS shelf in regards to D11C1 and D11C2 (EC 2017) and following the Technical Group on Underwater Noise (TG-Noise) recommendations.

The NWBS shelf comprises the entire Romanian offshore sectors and the western part of the Odesa Gulf from the Ukrainian offshore and adjacent onshore regions. According to the Anemone Project Deliverable 1.3 report **[1]**, for the Romanian BS waters, four Marine Reporting Units (MRU) were identified (Table 1, Figure 1).

Table 1. MRU for the NWBS shelf (Romanian waters), as MSFD requirements **[1]**

Broad habitat type (code)	MRU name	Depth limits (m)	Area MRU (km2)
Variable salinity	BLK_RO_RG_TT03	0-30	1358.95
Coastal	BLK_RO_RG_CT	0-30	1040.17
Shelf	BLK_RO_RG_MT01	30-200	20164.89
Open sea	BLK_RO_RG_MT02	>200	7058.25

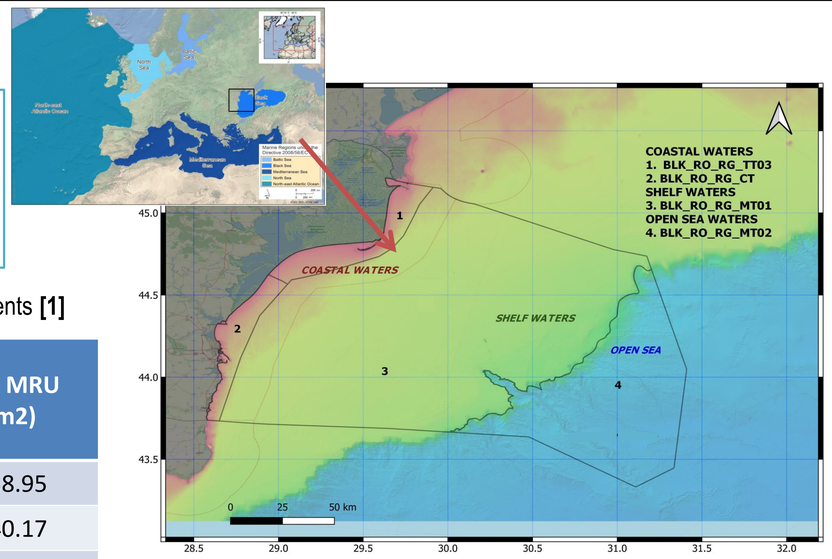
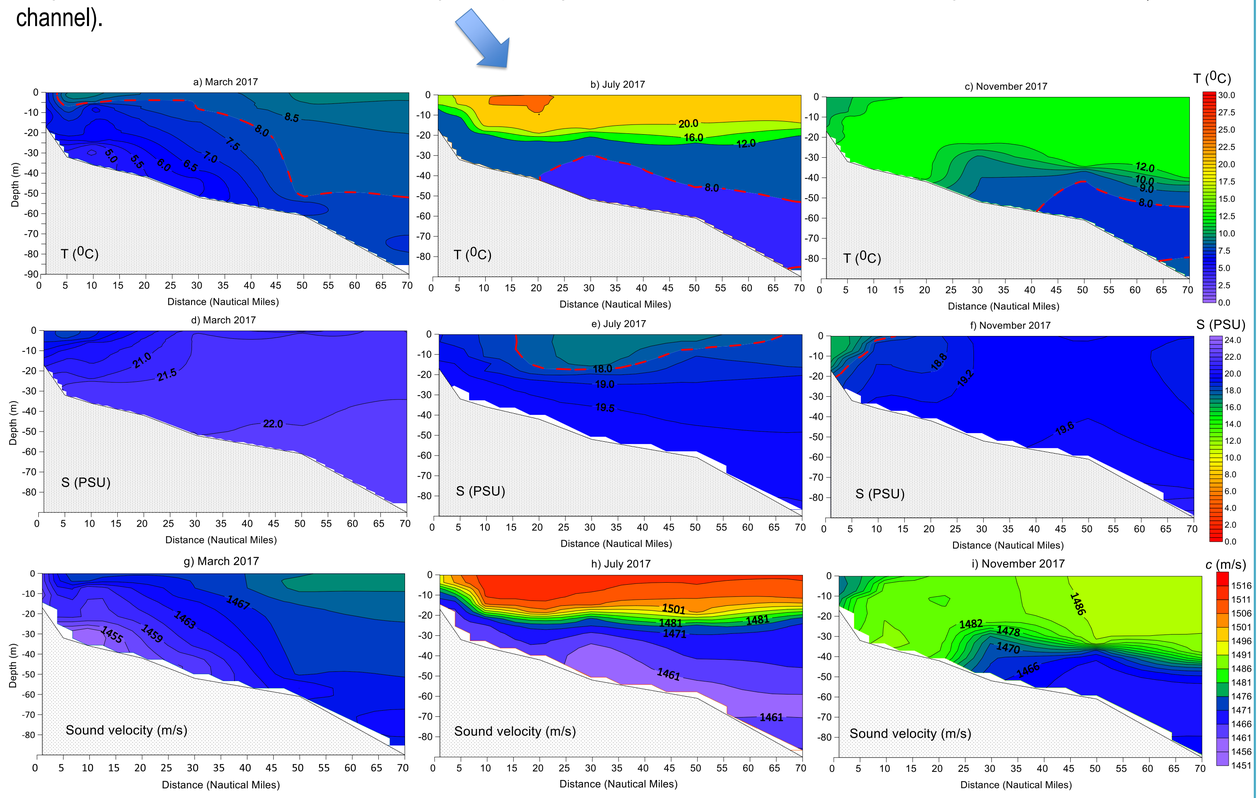


Figure 1 North-Western Black Sea (NWBS) shelf bathymetry, Marine Reporting Units (MRU)

D11C2. a) Sound speed profile along Constanta transect [2]

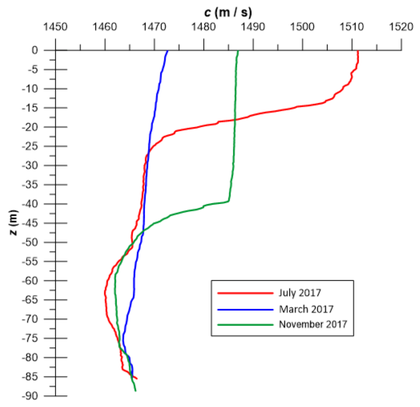
Seasonally, at Constanta offshore (about 70 nautical miles distance from the coast, 44°10'N) in the benthic layer, the sound speed reaches 1465m/s in spring (March), 1467m/s in summer (July – August) and 1466m/s during autumn (November). The seasonal variability of sound speed is limited by layer 0 - 80m and corresponds qualitatively to the seasonal variability of sea temperature.

The minimum is determined at the bottom of the thermocline (red line - summer). Therefore, below the thermocline, the sea temperature bides constant and as a consequence, the speed of sound increases because of the pressure increment (SOFAR channel).



In the Black Sea, seasonally, the predominant conditions for sound propagation (SP) can be described as follows: **winter - positive refraction**; **summer - negative refraction and propagation**; **autumn: a surface channel and propagation in the acoustic channel** **(or SOFAR = SOund Fixing And Ranging).**

The paper focuses on the oxic layer between 0 and 80m as the acoustic wave undergoes near-surface upward refraction in the upper mixed layer while due to the Black Sea's strong stratification, the sound speed is practically constant in the deeper layers.



b) Descriptive underwater background noise level statistics, in-situ data

In Table 2 and Table 3, descriptive statistics were achieved according to MRU-MSFD regions (Table 1) for noise data recorded on shallow and deep Romanian Black Sea waters. The configuration of the analysis is focused on third-octave band sound pressure levels.

Table 2 Descriptive statistics for recorded underwater noise for MRU Western Black Sea **(2019 – 2020)**

MRU name	Frequency	Mode (dB)	95th (dB)	RMS (dB)	SEL (dB)
BLK_RO_RG_TT03	63Hz	73.2	73.7	73.0	106.6
	125 Hz	67.0	73.5	67.2	97.6
BLK_RO_RG_CT	63Hz	71.5	92.5	78.5	105.8
	125 Hz	67.3	82.4	74.3	101.7
BLK_RO_RG_MT01	63Hz	72.8	74.3	73.4	103.8
	125 Hz	73.5	74.7	73.5	105.4
BLK_RO_RG_MT02	63Hz	74.7	74.7	74.3	104.0
	125 Hz	73.5	74.8	74.5	104.2

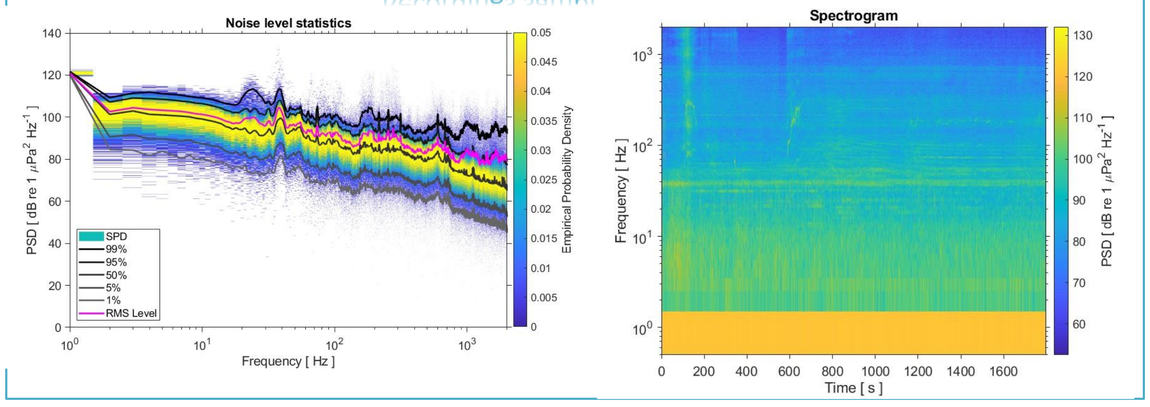
SEL characterises the potential effect of sound on marine mammals. The noise level distribution was within similar ranges for 1/3 octave bands for the 63Hz and 125Hz (designated for MSFD monitoring) for the summer of 2019 and 2020 (Table 2).

Higher levels are observed for the spring season of 2022 for all off-shore NW Black Sea MRU (Table 3). A total of 152 recordings/files with a time length of the 1200s/file were analysed.

Table 3 Descriptive statistics for recorded underwater noise for MRU Western Black Sea **(spring 2022)**

MRU name	Frequency	95th (dB)	RMS (dB)
BLK_RO_RG_TT03	63Hz	-	-
	125 Hz	-	-
BLK_RO_RG_CT	63Hz	-	-
	125 Hz	-	-
BLK_RO_RG_MT01	63Hz	101.6	87.6
	125 Hz	97.3	85.0
BLK_RO_RG_MT02	63Hz	121.6	100.6
	125 Hz	113.8	88.0

Recordings samples diagrams



CONCLUSIONS

Ocean noise is an essential component of the marine habitat. Overall, the implementation of the MSFD is the driving force in Europe today to address underwater noise.

Our study is an area of the North-Western Black Sea shelf - characterised by a relatively low topography – and the sound speed presents seasonally significant differences with a maximum negative gradient in summer due to the strong water masses stratification.

Hydrophone recording data from fixed locations păositioned along the Romanian Black Sea shelf for the short term were analysed to indicate the 1/3 octave spectra hourly Sound Exposure Levels (SEL) range that includes the natural soundscapes during the spring and summer seasons.

Fourteen data sets from 14 recording locations (Table 2) and 152 recording samples from 10 off-shore stations were analysed to indicate the 1/3 octave soundscapes with different types of human activity (shipping and touristic boats). Mode noise levels from the field recordings measurements from 2019 – 2020 on the NWBS shelf (corresponding to the Romanian Black Sea waters) ranged from 67.0 – 74.7 dB re 1 µPa, and the root-mean-square (RMS) level was lower than the 95th percentile. The lower frequency bands are more affected by the very shallow waters in BLK_RO_RG_TT03 (direct Danube influence) and BLK_RO_RG_CT (Table 2).

Significant background noise levels can be observed between the 2019 – 2020, and 2022 periods. The latter is closely related to maritime shipping as the leading contributor to noise pollution in the off-shore Black Sea waters (BLK_RO_RG_MT01 and BLK_RO_RG_MT02).

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