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Underwater noise analysis in the Romanian Black Sea waters as Marine Strategy Framework Directive of the European Union requirements

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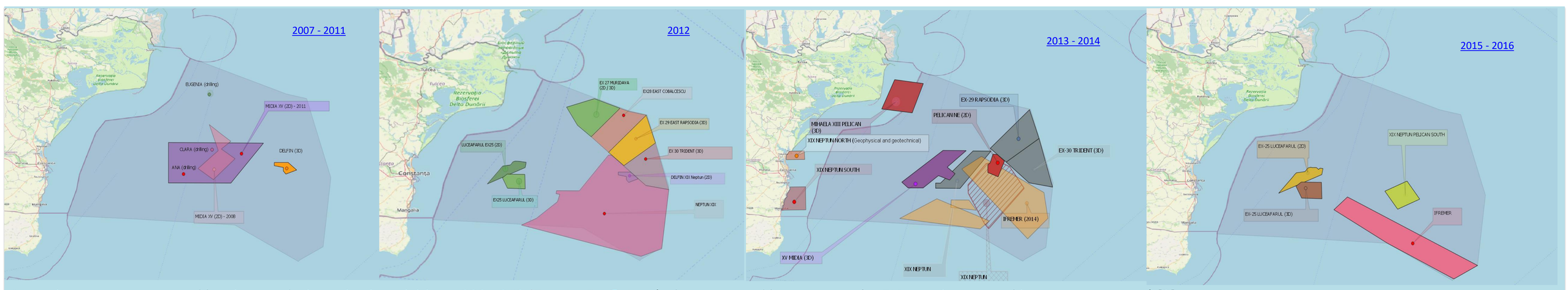
Abstract. The Black Sea is one of the world's unique seas as a semi-enclosed sea, and its ports are the eastern maritime frontier of the European Union. This paper aims to complement the work as is required in the Marine Strategy Framework Directive of the European Union (MSFD) Descriptor 11 noise-related criteria for anthropogenic impulsive sound in water (D11C1) and anthropogenic continuous low-frequency sound in water (D11C2). Statistically, the Romanian ports were handled about 14% of cargo traffic in Central and Eastern Europe during 2015 – 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). In addition, seismic acquisitions surveys registry that leads to future hydrocarbons (as Neptun Deep and Trident blocks – Romanian Black Sea) resource potential of the deep waters of the Black Sea and significant exploration of oil and gas activities and exploitation that have sat for the last ten years (D11C1) are assessed. For the initial impulsive noise registry of the anthropogenic impulsive sound occurrence impulsive (available data of sources since 2007 to 2018 period) for the North-Western Black Sea, the authors follow the underwater noise technical sub-group (TSG Noise) and QUIETMED / QUIETSEAS projects recommendations.

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 Hydrophone system). Current background noise levels in the Romanian Black Sea waters 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 2019 – 2020 recordings period. The current need for modelling of underwater noise pollution generated by anthropogenic sources, simulations for acoustic field propagation for different water depths (direct sound field, the sound field after reflection on the free surface, the sound field after reflection on the seabed) and an analysis of temporal and spatial variability of sound propagation conditions for the North-Western Black Sea are performed.

Keywords: underwater noise, Marine Strategy Framework Directive, hydrospatial analysis, noise registry, 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 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. The paper aims to establish the anthropogenic sources by assessing activities that can generate impulsive underwater noise in the North-Western Black Sea. The sound speed distribution based on in-situ data on the Romanian Black Sea shelf and initial modelling of underwater acoustic propagation, based on Bellhop model is performed.

D11C1. Impulsive noise map, during 2009 - 2016 [1]

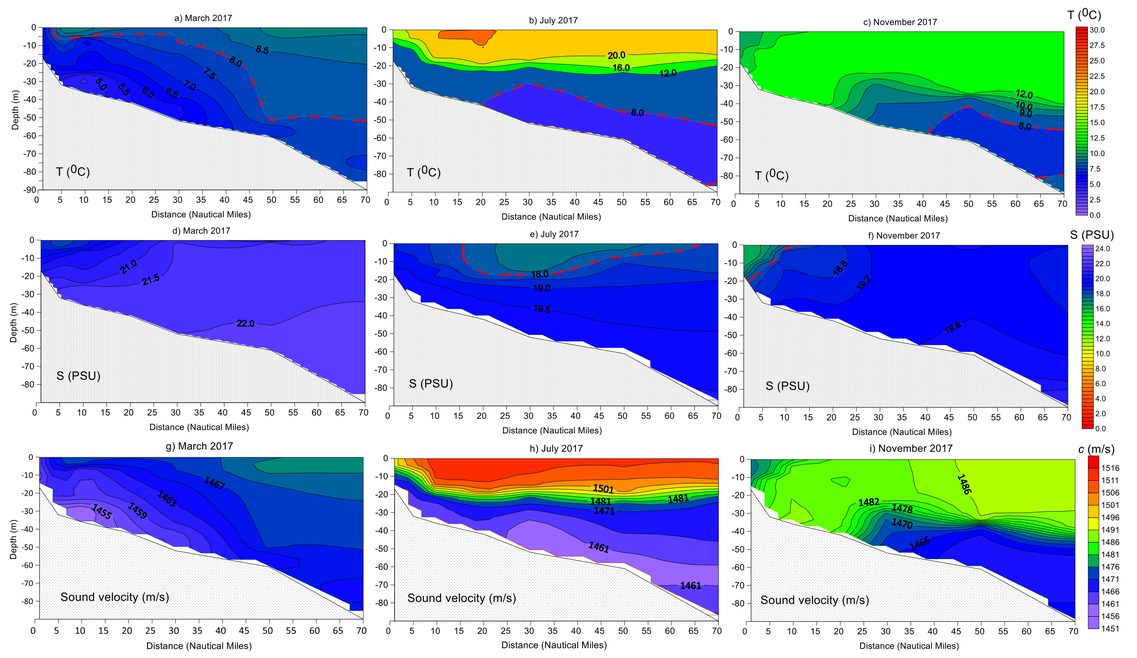


- Acoustic pressure generated by air guns during seismic activities = ***220 - 240dB re 1 µPa @ 1 m*** (values reported by operators for EIA - environmental impact assessment) [2].

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

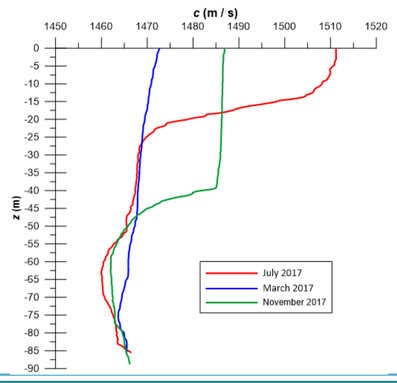
Seasonally, at Constanta offshore (about 70 nautical miles distance from the coast, 44°10'N) in the benthic layer, the sound speed reaches 1465m/s in spring (March), 1467m/s in summer (July – August) and 1466m/s during autumn (November). The seasonal variability of sound speed is limited by layer 0 - 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 in SOFAR**; **autumn: a surface channel and propagation in SOFAR (SOund Fixing And Ranging).**

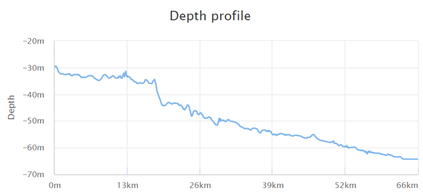
The paper focuses on the oxic layer between 0 and 80m as the acoustic wave undergoes a near-surface upward refraction in the upper mixed layer while due to the Black Sea strong stratification, the sound speed is practically constant in the deeper layers.



b) Descriptive underwater noise level statistics, in-situ data [3]

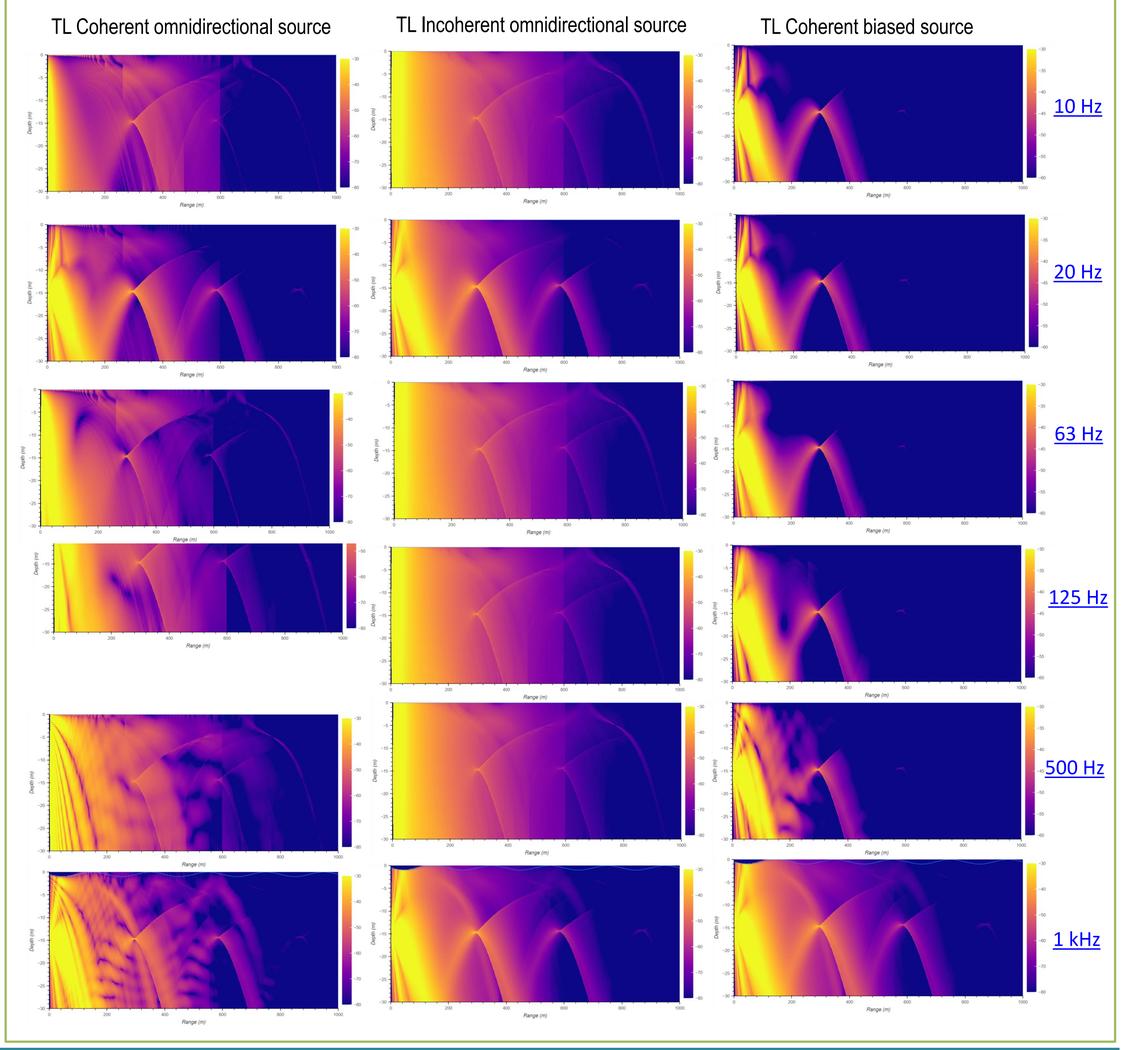
Statistics	1/3 SPL (dB re 1 µPa)	
	63Hz	125Hz
Median	72,19	69,79
Mode	72,49	70,54
RMS	75,65	73,87
95th Percentile	91,41	81,88

c) Modelling approach – Bellhop model [4]



Model setup, Phyton environment:

- hydrophone position at 1km distance from the source positioned at 10m water depth (44.4N / 29.0E) and transmitter (0-30m water depth and modelled in 601 points, the ship position at 44.3N / 29.8E); omni-dirrectional source
- Envorinmental inputs parameters are considered: bathymetry, sound speed profile (summer July 2017), wave (0.5m height)
- Output Computation– Transmission Loss for coerrent, incoerrent and biased for a distance up to 1000 m, 10Hz, 20Hz, 63Hz, 125Hz, 500Hz, 1kHz)



CONCLUSIONS

Our study is an area of the North-Western Black Sea shelf - characterized by a relatively low topography – and the sound speed presents seasonally significant differences with a maximum negative gradient in summer due to the strong watermasses stratification. For D11C1– MSFD, on the Romanian Black Sea continental shelf during 2007–2016 were identified 27 seismic surveys (2D and 3D) and several drillings, and the maps represent the first national register on impulsive noise D11C1. The airguns maximum intensity sound pressure level, during the seismic activities, varied from 220dB re 1 µPa @ 1 m to 240 dB re 1 µPa @ 1 m. No additional public information's are available for seismic surveys (e.g. seismic impulse-block days) or other impulsive noise sources, like: underwater explosions or military sonars. For D11C2, initial results are presented, using a beam/ray tracing model for predicting acoustic pressure fields for a limited study area for our specific underwater environment (BELLHOP model, publicly available as part of the Acoustics Toolbox [4]). The results shows a contour plot of the total transmission loss obtained via BELLHOP simulations of a source at 0-30m depth transmitting at 10Hz, 20Hz, 63Hz, 125Hz, 500Hz, 1kHz. It highlights the waveguide formed around the 15m depth caused by the sound propagation profile, propagating through more than 200m. The modelling results provide an significant input for future underwater noise assessments on the North-Western Black Sea.

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