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MITIGATE THE IMPACT OF HYDRO-ACOUSTIC NOISE ON THE SAFETY OF NAVIGATION AND MARINE ENVIRONMENTAL

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Introduction. Maritime shipping is a significant source of underwater sound in marine environments, emitting various frequencies depending on the vessel's size and operations. Primary sources of acoustic noise and vibrations include ship's mechanisms, main engines, diesel generators, propellers, as well as hydraulic turbulence and aerodynamic noise. Understanding the intricacies of these primary acoustic sources is crucial, as they collectively form a symphony of underwater vibrations that can have far-reaching implications for marine ecosystems. The need to comprehend and manage this acoustic symphony becomes paramount, considering the potential impacts on marine life, navigation safety, and the broader ecological balance. Beyond its ecological impact, hydro-acoustic noise plays a crucial role in the safety of navigation. The vibrations and frequencies generated by ship components can interfere with the accuracy of navigation equipment, posing potential risks to maritime operations. The harmonization of vessel speed, course changes, and main engine rotation frequency, as investigated in this research, holds implications for the precision of navigation instruments reliant on acoustics. Understanding how hydro-acoustic noise influences navigational accuracy becomes imperative for mitigating potential safety hazards at sea.

An in-depth exploration of hydro-acoustic measurements necessitates an understanding of the diverse types of hydrophones available. This includes omnidirectional hydrophones, directional hydrophones, and specialized models designed for specific frequency ranges. Each type caters to unique research needs, and their integration into the experimental setup influences the precision and scope of hydro-acoustic data collection. Hydrophones, as acoustic sensors, form the cornerstone of hydro-acoustic measurements. They serve multiple functions critical to scientific research, including capturing sound pressure levels (SPL), detecting characteristic frequencies associated with different ship components, and discerning hydroacoustic radiation patterns. The abstract advocates for real-time monitoring devices strategically positioned on ships, equipped with enhanced mathematical models informed by hydrophone measurements, to facilitate intelligent analysis for effective noise management. The accuracy and reliability of hydro-acoustic measurements are contingent upon adherence to conventional regulations and principles. This abstract recognizes the significance of aligning research methodologies with established guidelines, such as those set forth by international bodies like the International Maritime Organization (IMO), the Marine Environment Protection Committee (MPEC), and the International Maritime Organization (MARPOL). These regulations encompass standardized measurement procedures, calibration protocols, and data reporting requirements, ensuring the consistency and comparability of hydro-acoustic data across diverse maritime studies.

This scientific abstract proposes the development of complex mathematical and intelligent models for a systematic understanding and control of the influence of vessel speed, course changes, and main engine rotation frequency on the variability of infrasound spectrum propagation. Experimental results [1] demonstrate the feasibility of identifying noise sources on a ship when the rotation frequencies of the main engine, diesel generators, and ship mechanisms are known. The spectral distribution of sound pressure level (SPL) and characteristic frequencies associated with ship motion are illustrated in Fig. 1, obtained through hydrophone signals in the range of 5Hz–120 kHz.

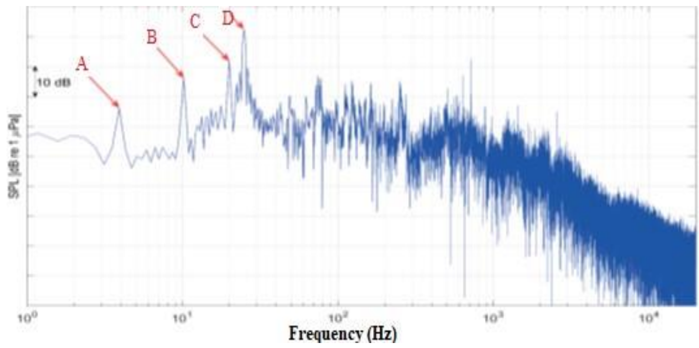

Fig. 1. A – 2 propeller shafts, rotational speed 234 RPM; B – 2 main engines, rotational speed 600 RPM; C – 2 propellers with five blades, rotational speed 234 RPM, D – generators, rotational speed 1500 RPM. The spectrum represents a 2-second signal when the ship was at its closest point of approach to the seabed

For instance, the maximum hydroacoustic radiation from a ship's propeller occurs at the frequency (See. Fig.1 curve C).

$$f = f_{rot} \cdot z, \qquad (1)$$

where z, is the number of propeller blades.

Promising research directions involve mathematical models derived from experimental data, unveiling dependencies between vessel speed, course changes, main engine rotation, and parameters of underwater acoustic wave propagation:

$$\Delta f = k \cdot V + m \cdot \theta - n \cdot S,\ \Delta I = a \cdot V + b \cdot \theta + c \cdot S, \qquad (2)$$

where Δf, is the change in infrasound frequency, V is the vessel speed, θ is the course change, S is the main engine rotation frequency, and k, m, n, a, b, c, are coefficients representing the relationship between frequency change and intensity of underwater infrasound (ΔI) concerning vessel speed, course changes, and main engine rotation speed, respectively.

Conclusion. The implications of this research abstract are far-reaching, extending into the realm of real-time monitoring devices strategically positioned on ships. These devices, informed by an advanced mathematical model, promise intelligent analysis for effective noise management. Aligning with contemporary conventions such as IMO, MPEC, and MARPOL [2], this abstract advocates for the integration of these devices to mitigate the impact of hydroacoustic noise on marine life and navigation safety. The proposed mathematical models empower the maritime industry to proactively control the propagation of acoustic noises, thereby contributing to the preservation and sustainability of marine ecosystems. In conclusion, this scientific research not only illuminates the intricacies of maritime noise but also charts a course towards practical solutions for environmental conservation and navigational safety. By leveraging advanced mathematical models and aligning with international conventions, our findings provide a foundation for the implementation of real-time monitoring devices, symbolizing a transformative step toward environmentally sustainable maritime practices. As we navigate the seas of progress, this research beckons to harmonize the imperatives of maritime commerce with the imperative to safeguard the health and vitality of our marine ecosystems.

References:

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