HYDROACOUSTICS
4, 161-164 (2001)

THE CHARACTER OF UNDERWATER NOISE RADIATED BY SMALL VESSELS

Stefan Jan Malinowski[1],Ignacy Gloza[2],Jacek Domagalski[1]
[1] Naval Test and Evaluation Ranges, 81-103, Gdynia – Oksywie 3
[2] Naval Academy, ul.Smidowicza 69, Gdynia, Poland
e-mail: igloza@amw.gdynia.pl

This paper presents an overview of our initiatives for underwater noise measurements and their acoustic characteristics, which years ago have been applied. Different kinds of surface ships and more importantly submarines radiate high levels of underwater noise which can be detected and tracked by passive sonars. Hostile navies use these signatures for detection and classification of targets. In many cases, not only a vessel as a specific class of warship, but also even the individual ship within a concrete class can be positively identified. The method of narrow-band filtration of the spectrum's discrete lines at frequencies up to several Hz is the basic standard of passive systems for long-distance detection. To find the source of noise, the level of vibration was also measured by accelerometers. Ship's very own distinctive acoustic signature radiated at discrete frequencies, excited by the machinery, is easily detected and must be decreased as much as possible. Coherence between underwater sound pressure from a moving vessel and vibration during the same run was made.

INTRODUCTION

Anyone who has spent time aboard a small vessel knows that vibration and noise is always a major problem there. High noise levels can also distort speech clearness that confuse routine conversations and also reduce a crews' ability to relax during rest periods. Underwater noise influences in the depth weaponry and acoustic torpedoes. Thus, minimizing excessive air and underwater noise could result in better crew performance and increase the stealth against the underwater threat. Noise levels in accommodation areas of small vessels would range from 60 to 80 dB (A). Other spaces on ship have much higher noise levels. The engine rooms are the noisiest areas and have levels ranging from 90 to 120 dB (A). High vibration levels often occur in the aft ship due to propeller cavitation during manoeuvring. Vibrations aft are often local and not measurable in forward part of the ship. Experience has shown great dissimilarities in the vibrations caused by analogous procedures, depending on different combinations of propeller pitch and revolutions per minute used by the officers. The classic acoustic source /path approach was used to investigate noise sources and paths associated with the transmission of machinery noise. It is important to remember that total systems approach should be maintained, all noise sources inside a given space were considered.

1. METHODS OF MEASUREMENT

The underwater-radiated noise and vibration measurements were carried out in Gdansk Bay area in August 2000 so at this time the sound speed profile was typical of the summer, little by little decreasing gradient without mixed layers. During the ship measurements, the average wave heights were less than 1 m and wind speeds less than 5 m/s, so the ambient noise level was low. The vessel under test was running at a constant speed and course. In order to correctly predict the acoustics source levels of different kinds of surface ships and submarines, a description of low-frequency sea ambient noise is available. The bottom-mounted hydrophone range is very useful for measuring the noise of surface ships. What more when we use bottom-fixed hydrophones the irrelevant low-frequency wave-induced noise is also eliminated. Throughout this measurement, the signal-to-noise ratio for the spectrum data was greater then 28 dB.

In a stationary condition, the ship was anchored above the middle of four hydrophones, thus the generated noise of machines operated inside the ship was measured without any interference of hydroacoustic field. In order to identify the noise source, vibration level at the bottom of each ship section was measured using accelerometers, which were utilized to monitor vibration level inside the ship. When the ship was rigid, we created on-board vibration plus underwater noise-analysing systems. The total measurements were taped using an analogue recorder and simultaneously two-channel digital analyser was applied.

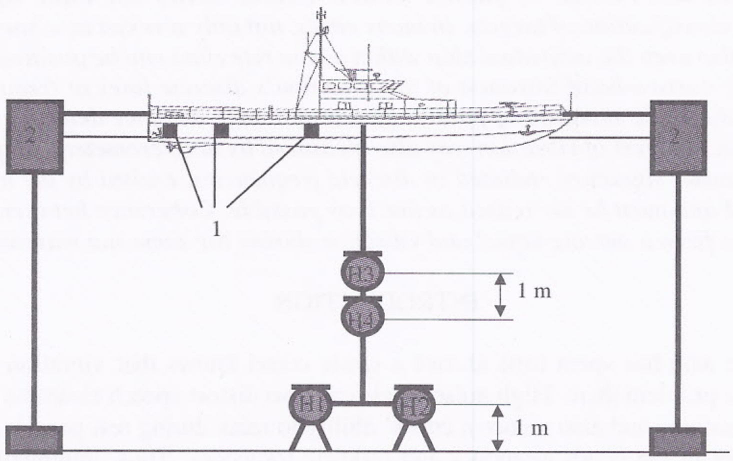

Fig.1. A stationary underwater acoustic test and evaluation range.
1-accelerometers, 2- anchor buoys, H1, H2, H3, and H4 – hydrophones.

Since we have started our measurements various types of hydrophones and hydrophone arrays have been employed for this purpose. Recently in a sailing condition, the recordings were carried out by means of an array of Polish Naval Academy hydrophones, which were strung in a line along the bottom in shallow water. We are going to note that the noise level of a specific vessel does not remain constant. During its service life, ships wear out and their mechanisms become old and often unbalanced, so their noise levels grow on average by 6 dB. Not only does a high level of generated noise is far more vulnerable to detection; this also inhibits the vessel's skill to operate its own acoustic sensors.

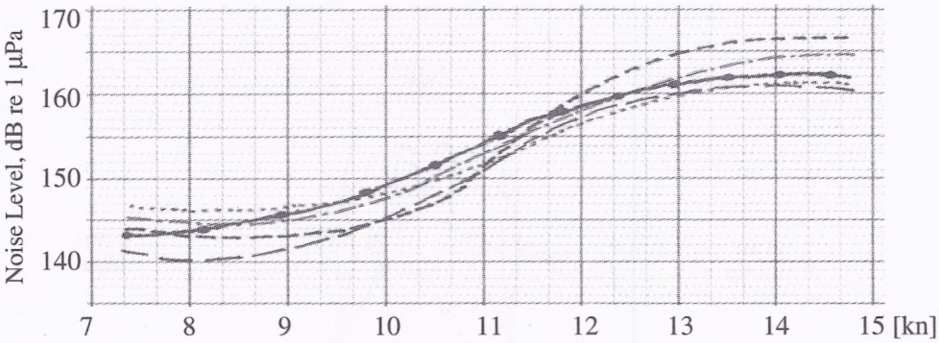

Fig.2. Underwater sound pressure levels from surface ships of the same type. As the speed of the vessel increases, there is a critical speed at about 10 kn where propeller cavitation begins.

2.DIRECTIONALITY OF SOURCE LEVELS

One of the key objectives of our measurement programme was to determine the directivity of some mechanisms of the ship noise. The directionality is understood as contours of source level plotted on a hemisphere centred at the area of the midships. Figure 3 shows the equal pressure contours detected on the bottom of the sea of a surface ship at a speed of 16 knots. These contour values are pressures in dynes per square centimetre. Screening by the hull in the fore-and-aft directions and by the wake at the rear gives less underwater noise forward and aft than into quarter aft.

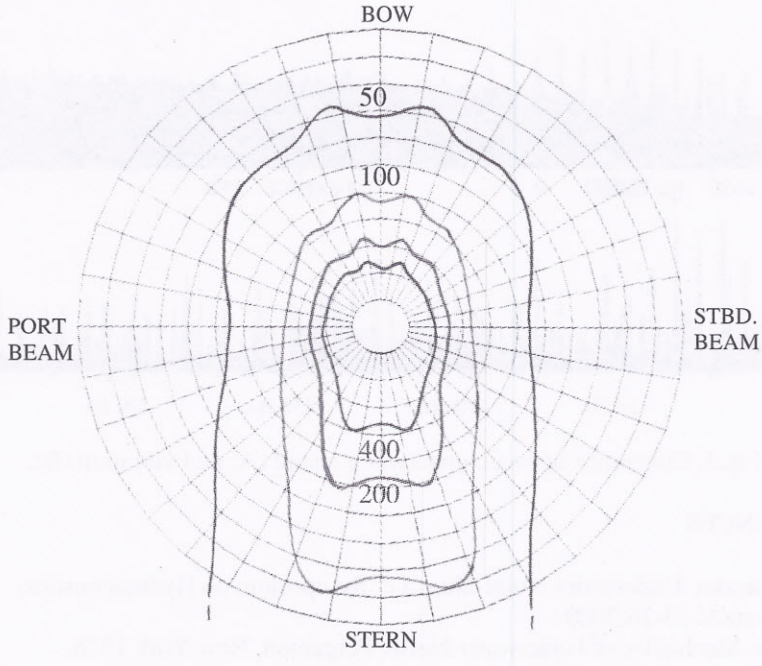

Fig.3.Equal pressure contours of a vessel at a speed of 16 knots.

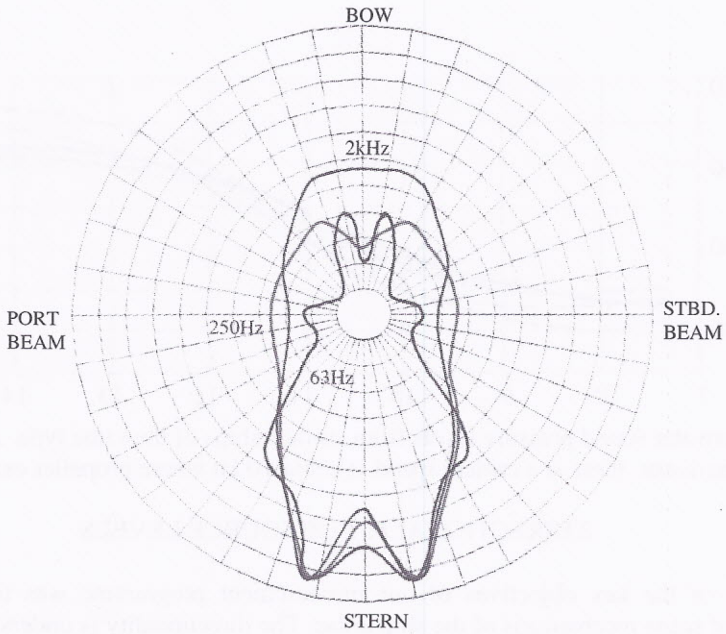

Fig.4. Directionality of 63 Hz, 250 Hz and 2 kHz octaves from a surface ship.

Coherence between underwater noise signal and vibration measured at the same time is shown in figure 5. The coherence,γ is calculated as: $\gamma^2 = |G_{AB}|^2 / G_{AA} \cdot G_{BB}$

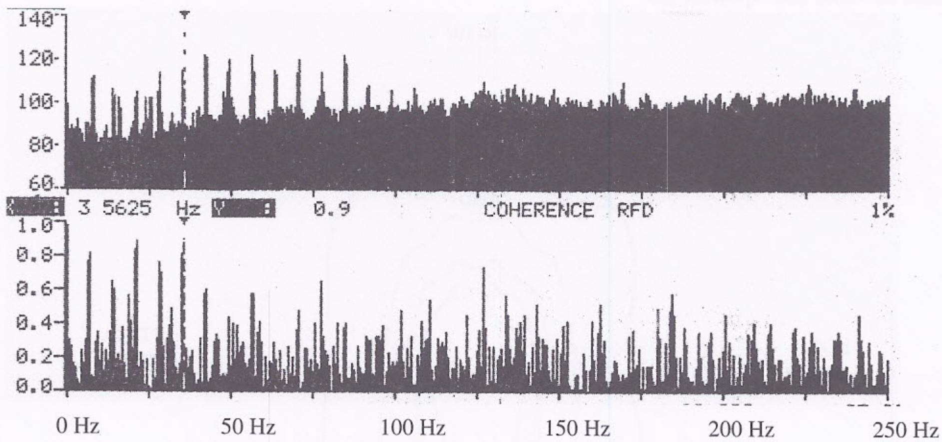

Fig.5. Coherence between underwater sound (A) and vibration (B).

REFERENCES

1.E. Kozaczka: Underwater Noise Ship. 17th Symposium on Hydroacoustics, Juarata,V 23-26,2000.
2.D.Ross: Mechanics of Underwater Noise, Pergamon, New York 1976.