

# **SPATIAL DISTRIBUTION OF UNDERWATER SOUND GENERATED BY HULL OF MOVING SHIP**

**KAROL LISTEWNIK**

Hydroacoustics Institute, Polish Naval Academy  
Śmidowicza 69, 81-103 Gdynia, Poland  
K.Listewnik@amw.gdynia.pl

*The paper presents the experimental research associated with the spatial distribution of acoustic energy generated by moving ship into the water. The paper present the methodology of evaluations acoustics energy from the mechanisms of ship into the water environment. For that purpose the research of noise spatial distribution over ship's hull were conducted along with the hydroacoustic field. The hull is source of waves of complex surface shape inducing waves of different amplitudes and phases depending on the position of ship's machinery. As a result of the hull vibrations generated wave distribution depending on the primary sources, as the main propulsion units, generators or other mechanisms. This research allowed to determine position of the main noises' sources of acoustics energy of machinery and propulsion system depending on class of ships and to designate spatial distribution of noise generated by hull of moving ship.*

## **INTRODUCTION**

The scientists of Hydroacoustics Institute of the Polish Naval Academy more than thirty years leads investigation related with experimental research the transmission of the acoustic energy generated by moving objects into the sea water. The research are provided for the following aims:

- Scientific research/investigations,
- Passive ship defense,
- Monitoring self underwater noise,
- Protecting of water environment (sea mammals),

- Classification and identification objects,
- Reconnaissance of sea object,
- Description of the technical state of ship,
- Influence mine-sweeping,
- Development of passive hydroacoustics systems.

These results are very important for save people and warships during duty at the sea. This paper presents chosen and results of investigations lead in the Polish Navy and used to determine the distribution of ships noises on the bottom of sea.

The main aim of investigations were:

1. The determine of distribution of underwater noises on the bottom of sea,
2. To expand the methods of hydroacoustics investigation about spatial distribution of hydroacoustics noise chosen ships.

## 1. METHOD OF INVESTIAGTIONS

The main method of investigations is dynamic method of measurement underwater noises. The sensors there are directly on the permanent special construction situated on the bottom of sea. The directional buoys lead ship straight above underwater section of hydrophones. This method allows calculate longitudinal and transverse (spatial) distribute of underwater sound generated by hull of moving ship. The measurement transverse and spatial distribute of underwater noises required more than one sensor, but investigation longitudinal distribute acoustic energy emitted by hull of ship don't require more than one sensor. During this investigations eight hydrophones was used. The appearance of range where were made investigations is presented in Fig.1.

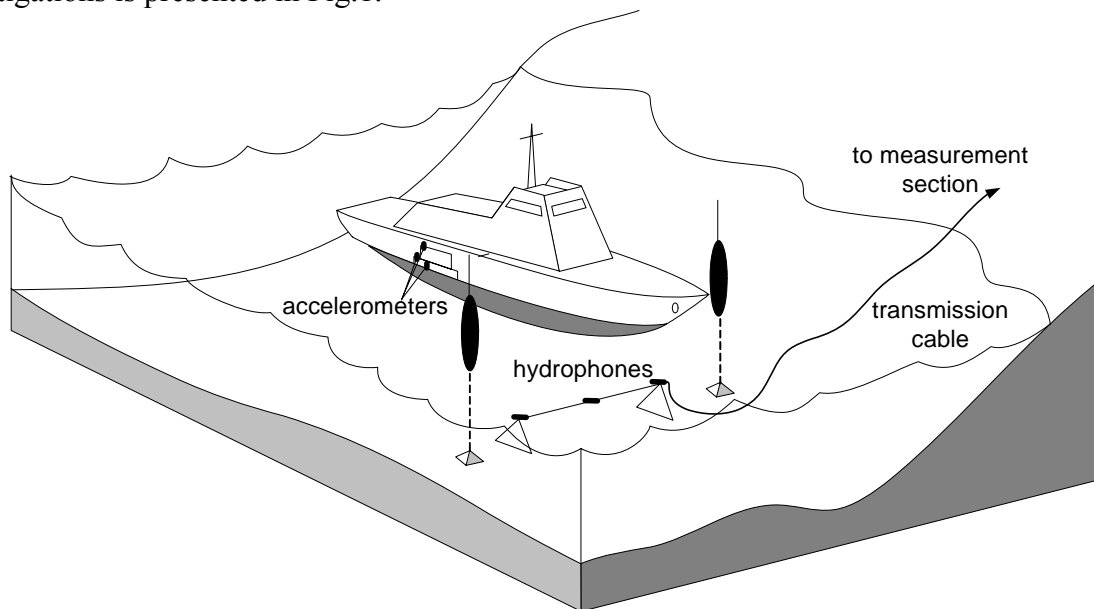


Fig.1. The dynamic measurement of ship's noise – one of the method of the investigations sources and spatial distribution of ship's underwater noise

In dynamic method of hydroacoustic measurements requires the knowledge about harmonics of main sources of noises. That can be realized by a few ways. e.g. two groups of researchers take part in investigations. First group on the acoustics range measure underwater noises and second group on the board of investigated ship measure vibration the main sources of sound. Another way is usage previous investigation of ship vibration with the same settings of parameters of mechanisms of ship. This method allows to check correctness measured records underwater noise [1]. The examinations are conducted on the different depths.

## 2. RESULTS OF RESEARCH

The knowledge about position of harmonics of main mechanisms in spectrum of ship's underwater noise is very important [2]. Harmonics of main mechanisms almost always appears in the spectrum of underwater sounds. The main sources of ship's underwater noise consist of noises generating by [3]:

- The hull of ship,
- The main engines, e.g. gas turbines, diesels,
- The auxiliary system of ship e.g. generating sets, pumps, compressors, steering devices,
- The propellers,
- The energy – electrical system e.g. generators, transformers,
- The pulses in a long pipes, cyclical compression of liquid and gaseous,
- The aerohydrodynamical effect of elements of a hull.

In this examinations the harmonics related with the ship's mechanisms. The comparison of physical dimensions of researched ship with spatial distribution of measured under hull sound allows to describe the areas of the maximum transmissivity of acoustics energy. Acquirement knowledge is necessary during project phase of ships construction especially military applications. Idea of location the main sources of underwater noise is presented in Fig. 2.

The method based on characteristics harmonics tracking in  $k$  records, where  $k$  depend on length of measurement data and length of ship.

The dozen ships were being analyzed, every at different parameters of the operating of ship's mechanisms. It was noticed that every ship have an individual image, which distinguish it from other ships. Some results for four chosen ships is presented in Fig. 2 and 3. In this article four ships of different types and sizes moving with the comparable speed from 9 to 11 knots were compared. We can see that the distances between main sources underwater noises aren't comparable. It is allowed in the further investigations to test all sources witch appear in the tested files and to describe its shape. The calculated distances are similar to really length of investigation ships.

The knowledge about spatial distribution of hull of ship's noises is very important, because of strivings to minimization of areas of hydroacoustics sound pressure of moving ship. The comparison of ship's noise sources and areas of sound level pressure on the bottom of sea allows tracking influence of different class of ships with different settings of parameters of mechanisms of ship on the level detection devices (e.g. mines) in the chosen area.

Some results for two chosen ships is presented in Fig. 4, 5, 6 and 7.

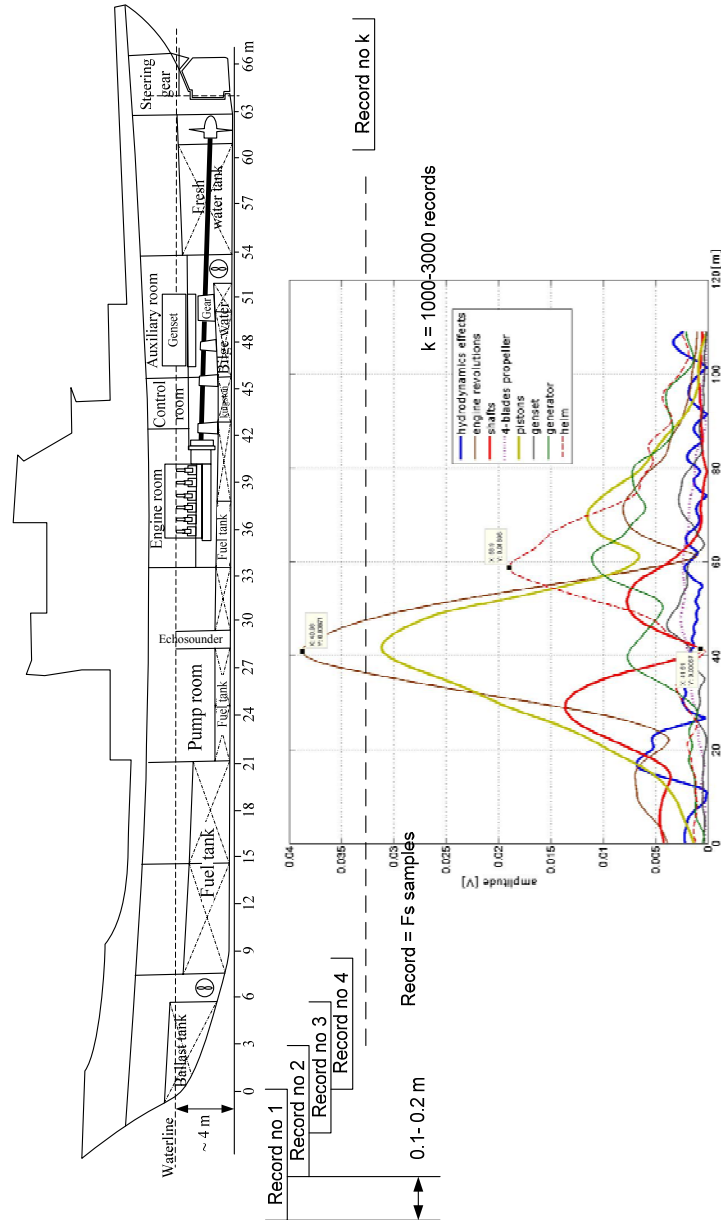


Fig.2. The dynamic measurement of ship's noise – the method of measurement and analyze of longitudinal distribution of sources of underwater noise ship no 1, speed 10 knots

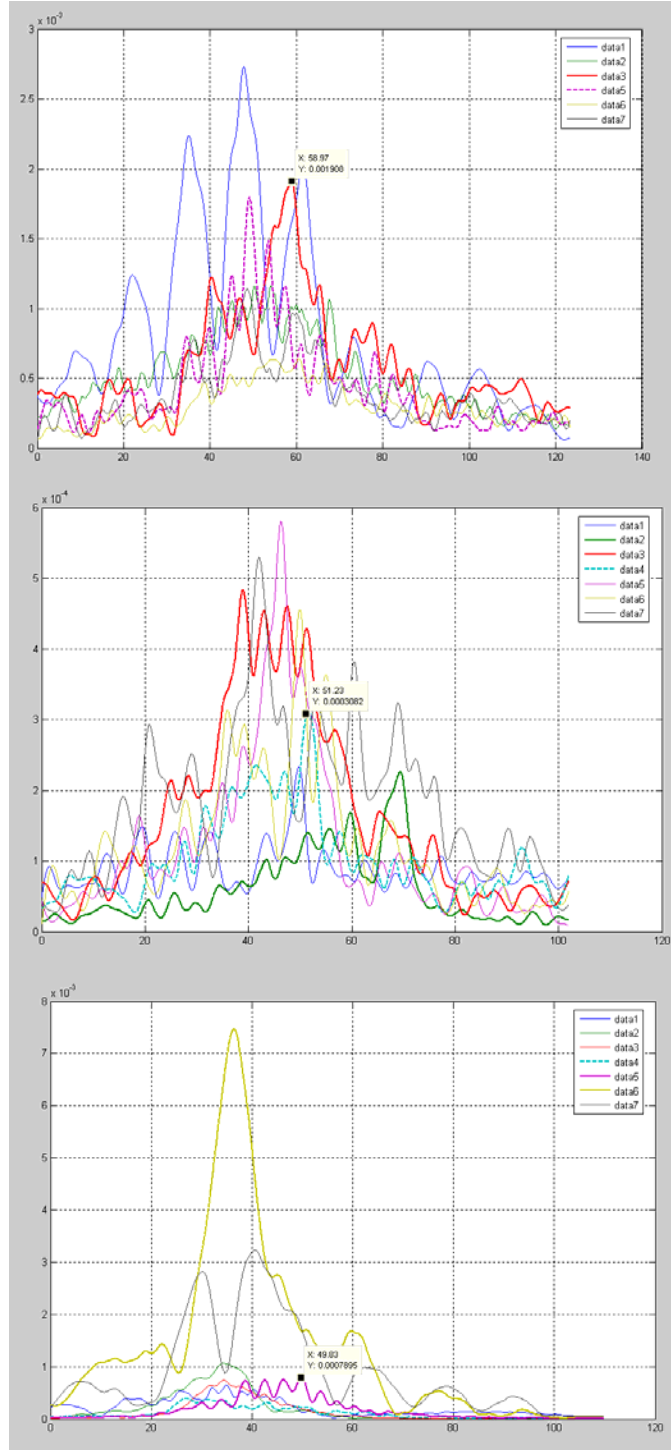


Fig.3. the analyze of longitudinal distribution of sources of underwater noise: Upper diagram: Ship 2 –Speed 9,6 kts, Generating set marks dotted line, the accentuation line - engines. Middle diagram: Ship 3 – speed 11 kts, Generating set marks dotted line, the higher lines - engines. Lower diagram: Ship 4 – speed 9 kts, Generating set - accentuation line, the higher lines - engines

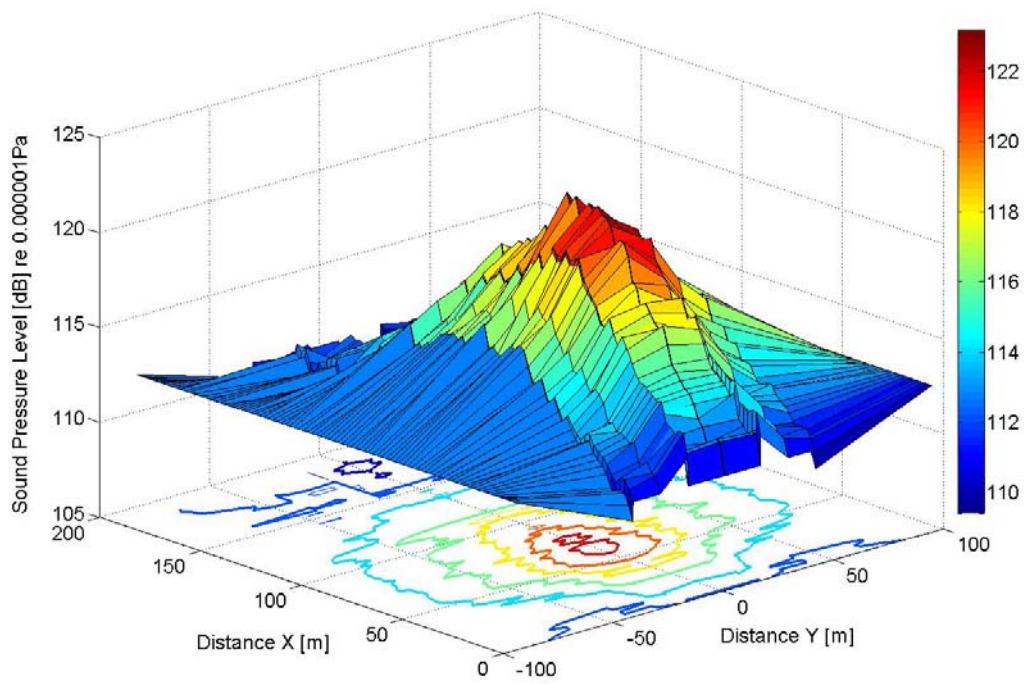


Fig.4. The analyze of spatial distribution of sources of underwater noise: ship 1, speed of ship = 8 kts. Measurement's depth = 20 m

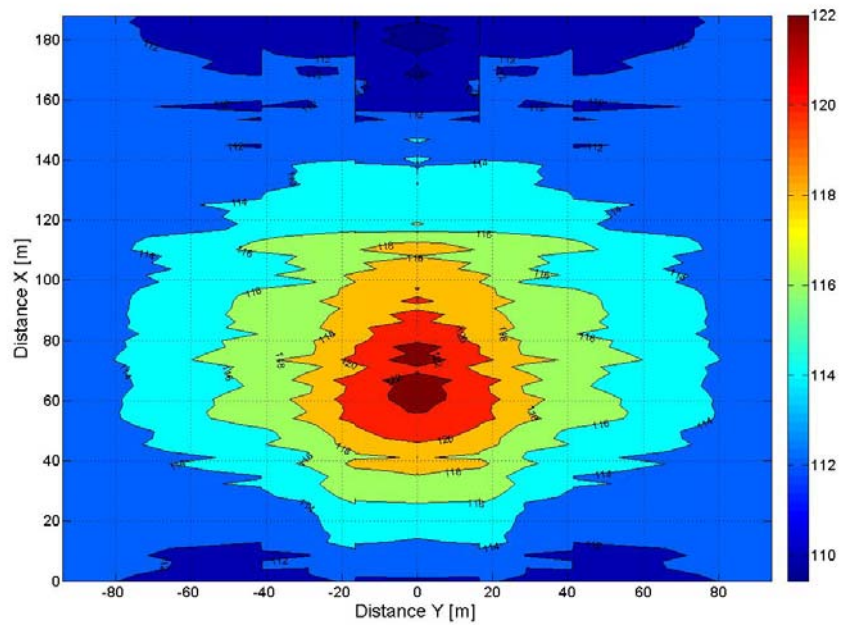


Fig.5. The spatial distribution of underwater noise of ship's hull: ship 1, speed of ship = 8 kts. Measurement's depth = 20 m

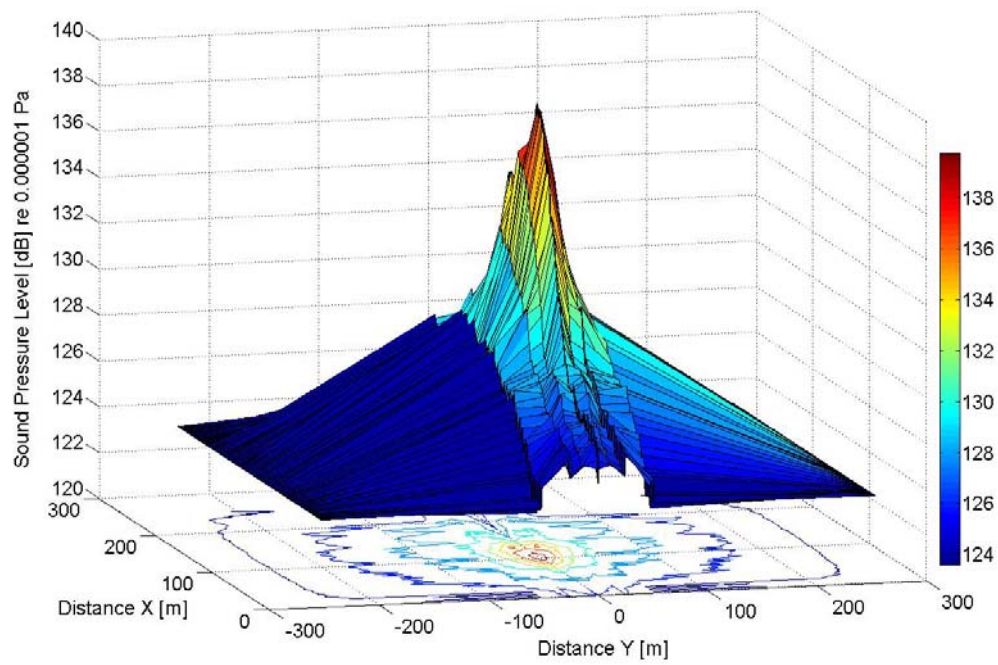


Fig.6. The analyze of spatial distribution of sources of underwater noise: ship 3, speed of ship = 12 kts.  
Measurement's depth = 20 m

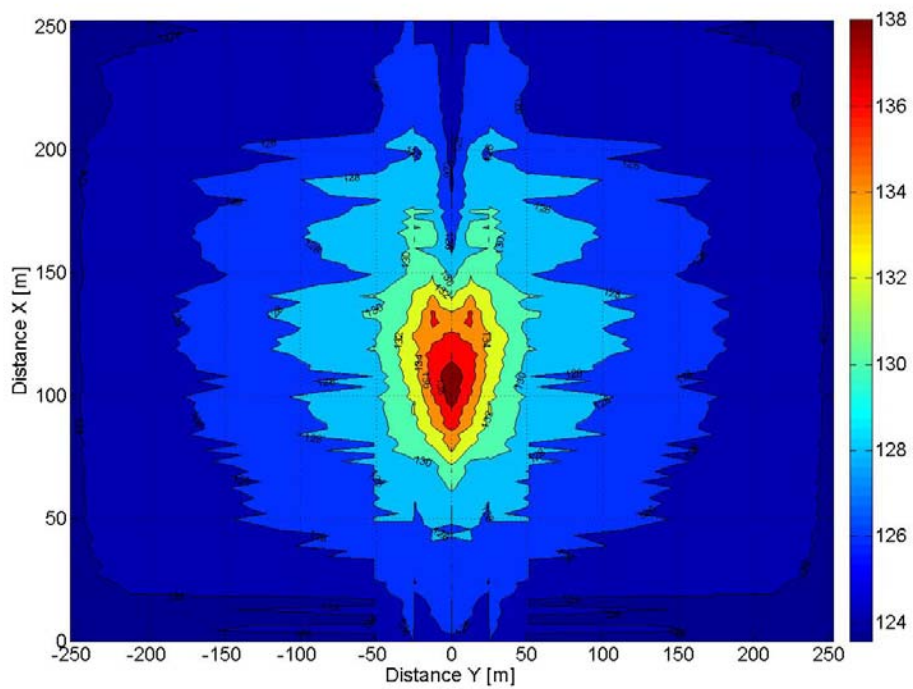


Fig.7. The spatial distribution of underwater noise of ship's hull: ship 3, speed of ship = 12 kts.  
Measurement's depth = 20 m

### 3. SUMMARY

The preliminary research of spatial distribution of the areas of the highest noise levels of hull of ship allows to conclude:

1. Based on the measured underwater noise generated by ship it is possible to get conclusion about distances between main sources of underwater noises generated through hull of investigation ship.
2. The experience gathered during research localization the areas of the highest noise levels of hull of ship could help minimalisation acoustics signature of ships.
3. The comparison of physical dimensions of researched ship with spatial distribution of measured under hull sound allows to describe the areas of the maximum transmissivity of acoustics energy.
4. The comparison of ship's noise sources and areas of sound level pressure on the bottom of sea allows tracking influence of different class of ships with different settings of parameters of mechanisms of ship on the level detection devices (e.g. mines) in the chosen area.

### REFERENCES

- [1] E. Kozaczka, I. Gloza, Determination of the ship signature in the very shallow water, *Proceedings of the 14<sup>th</sup> International Congress on Sound and Vibration*, 6 pp., CD., Cairns 2007.
- [2] K. Listewnik, Investigation of influence of ships generating set on emitted acoustic energy when the ship was anchored and during movement of it, *Proceedings of 51-st Open Seminar on Acoustic*, 407- 410, Gdańsk 2004.
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