

# THE PRIMARY SOURCES OF SHIP NOISE OBSERVED ON THE BOTTOM OF SEA

KAROL LISTEWNIK

Polish Naval Academy  
Smidowicza 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 shallow water. Moreover, the paper present the methodology of determination of acoustics energy from the main mechanisms of ship into the water environment. For that purpose the research of noise spatial distribution of the ship were conducted along the hydroacoustic field. This research allowed to determine ship signature spatial distribution of chosen main mechanisms on the bottom of sea.*

## INTRODUCTION

The ship is a complex source of underwater noises which are unique like fingerprints. The hull vibrations are generating waves which depends on the primary sources such as the main propulsion units, generators or other mechanisms. In military technique, this fact is used to detection, classification, identification of type of moving ship and estimation ships movement parameters. Furth more, knowledge about underwater ship noise is relevant part of passive defense therefore it is necessary to build self-monitoring noise system and marine mine countermeasure (MMCM) systems.

The researches 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 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 chosen main mechanisms hydroacoustic's noise ship.
3. To test correctness of new acoustical range developed for The Polish Navy.

## 1. METHOD OF INVESTIGATION

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.

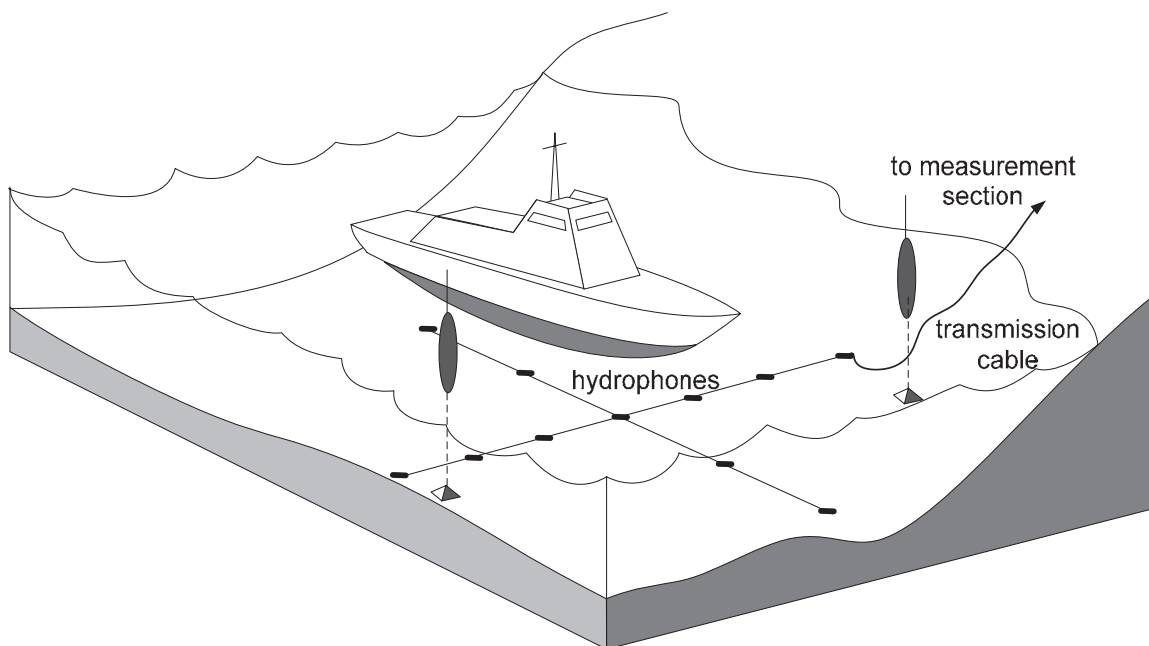


Fig.1. The dynamic measurement of ship's noise – one of the method of the investigations sources and spatial distribution of underwater noise

The 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 were conducted on the 20 m depth.

## 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 evaluations of the transmission of low frequency vibration from the mechanisms of ship into the water environment is especially important because of the widest and the further range. The analysis of low frequency band allows to determine source characteristic such as:

- Number of shafts and multiple shafts effects,
- Shaft rate,
- Number of propellers blades,
- Frequency of current generated by generating sets,
- RPM of main engines and generating sets,
- Cavitations effects,
- Detection of changes of sources e.g. 1. Shift in frequency caused by change in the propeller revolution rate, 2. Changes of vibration level or underwater noise depend on technical state of ship.

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. In this examinations the harmonics related with the generating sets were a base of localization another ship's mechanisms. Idea of location the main sources of underwater noise is presented in Fig. 2. and Fig 3.

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 one chosen ships is presented in Fig. 2, 3, 4, 5 and 6. 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.

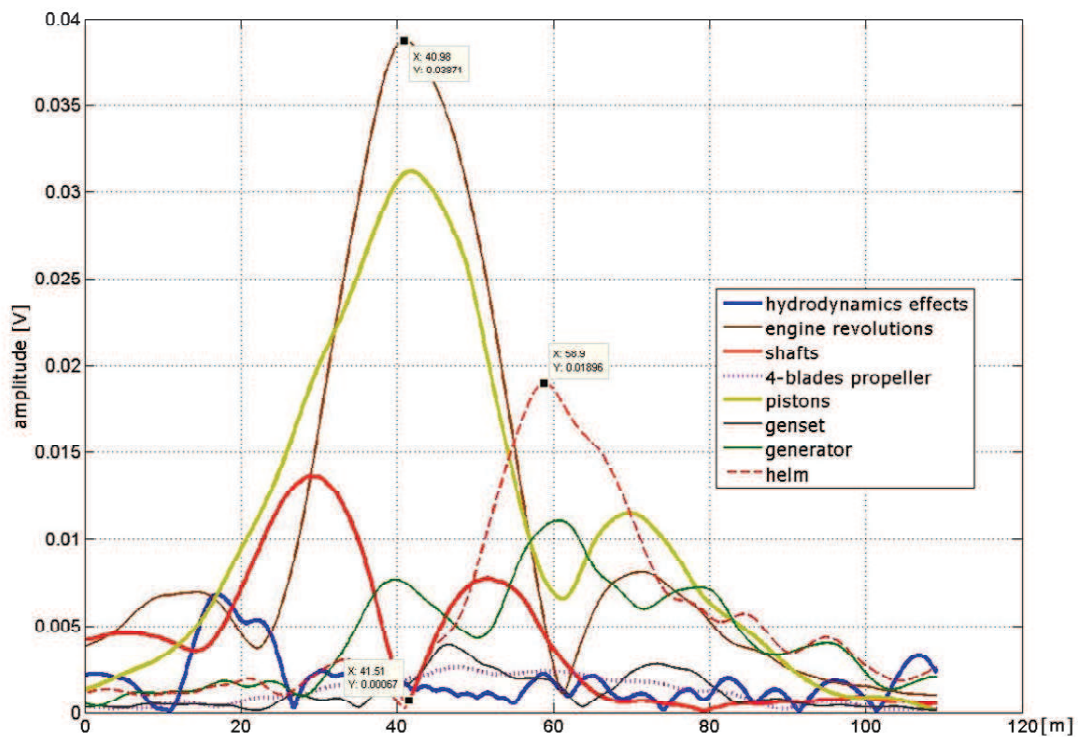


Fig.2. The main sources of ship's underwater noise of investigation ship

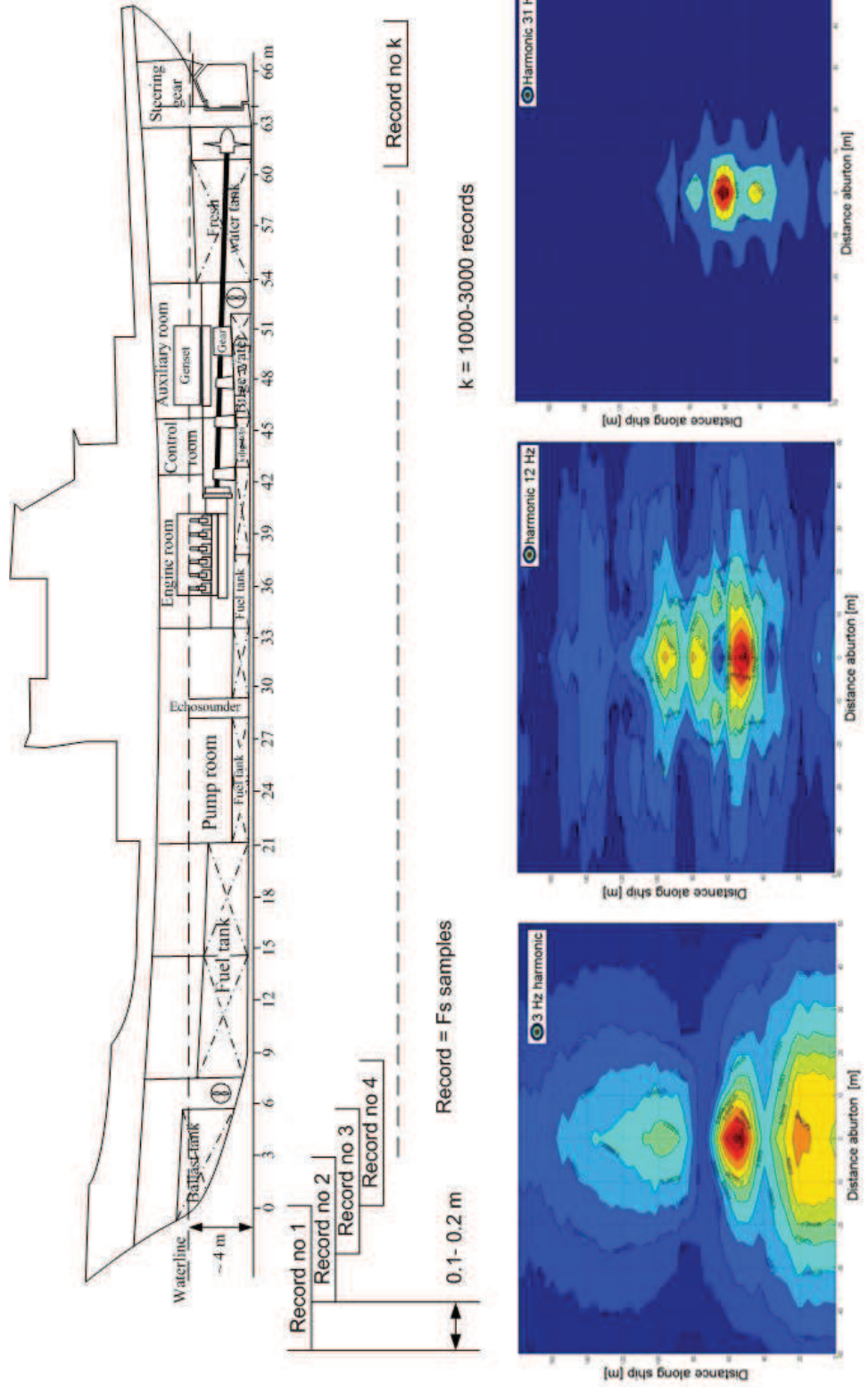


Fig.3. The dynamic measurement of ship's noise – the method of measurement and analyze of longitudinal distribution of sources of underwater noise chosen ship, speed 10 knots

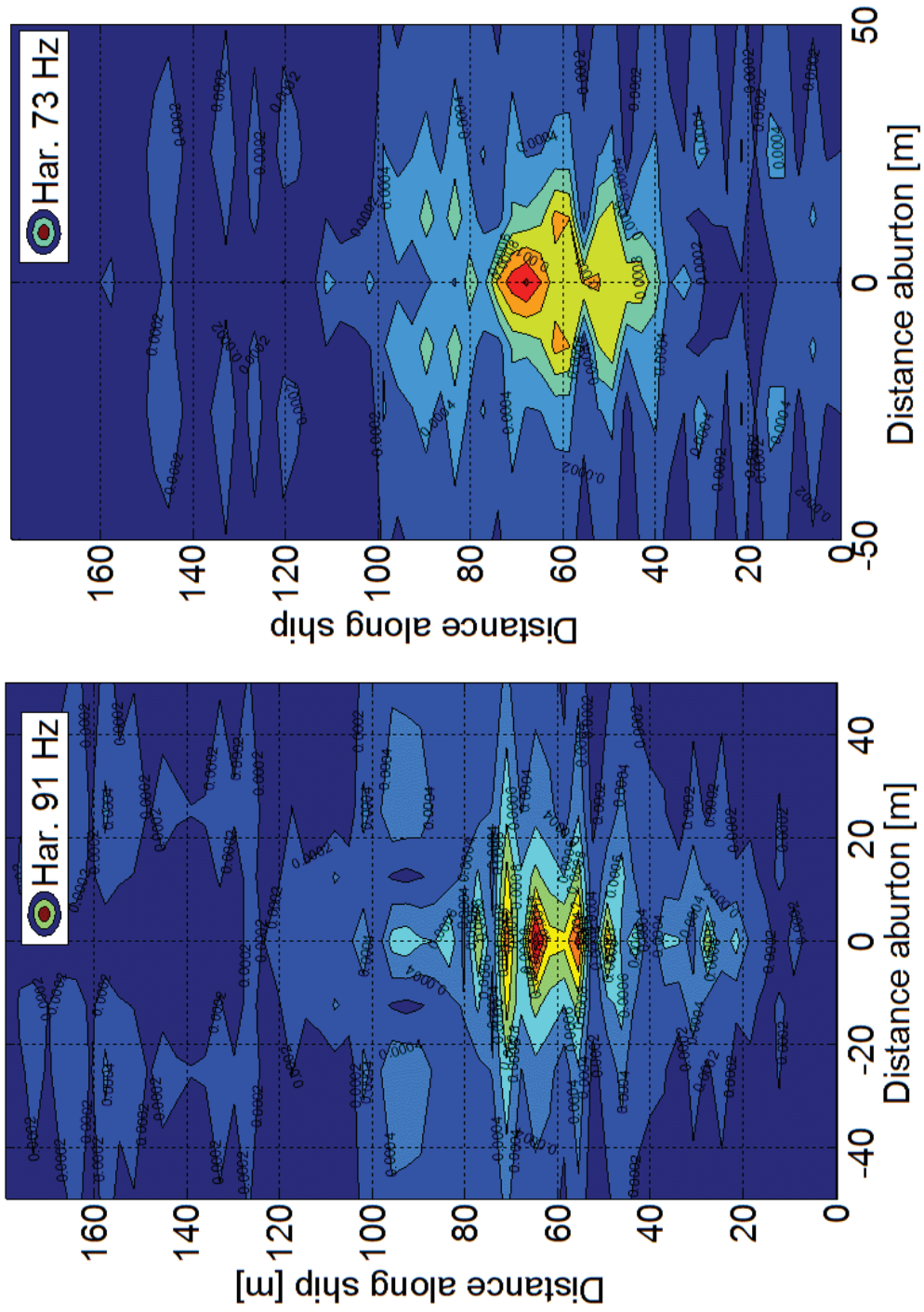


Fig.4. The dynamic measurement of ship's noise on the bottom of sea— results of spatial tones analyze

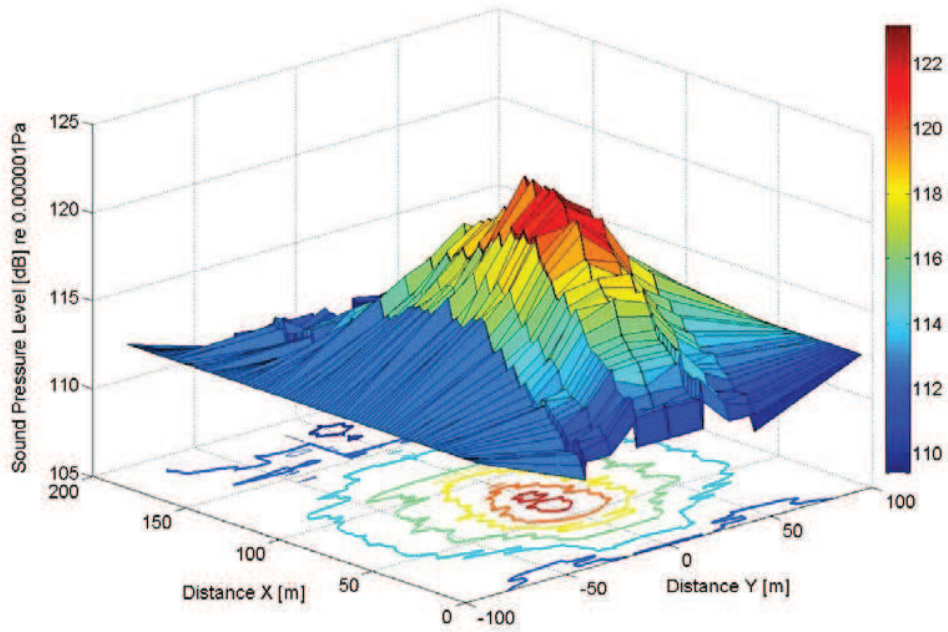


Fig.5. The analyze of spatial distribution of sources of underwater broadband noise: ship 1, speed of ship = 8 kts. Measurement's depth = 20 m

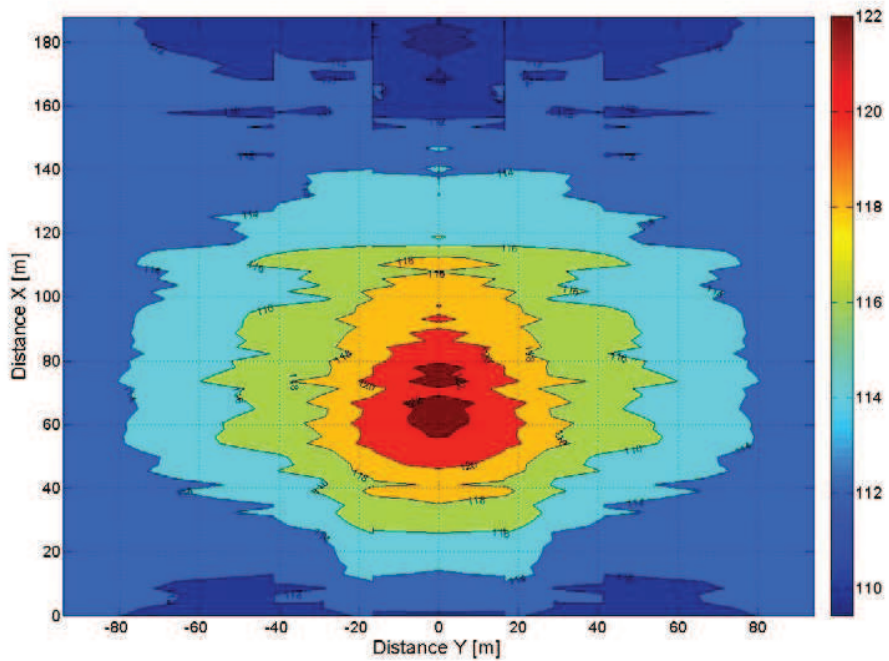


Fig.6. The spatial distribution of underwater broadband noise of ship's hull: ship 1, speed of ship = 8 kts. Measurement's depth = 20 m

### 3. SUMMARY

The calculation of spatial distribution of the areas on the bottom of sea 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 influence main sources of underwater noises generated throw hull on water environment.
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*, pp. 407- 410, Gdańsk 2004.
- [3] K. Listewnik, Influence of vibration of ship's generating set on emitted acoustic energy, *Hydroacoustics, Vol. 9*, pp. 97-102, Gdynia 2006.