Acoustic signature of two Spanish oceanographic ships

PACS REFERENCE: 43.

Santiago, J. Salvador; Carbó, Rafael
Instituto de Acústica, CSIC
Serrano 144,
28006 Madrid
Spain
915618806
914117651
e-mail: iaccf31@ia.cetef.csic.es

ABSTRACT

The acoustic signature of an oceanographic ship that could be used to improve fishing techniques, detection of fish schools, etc. is an important characteristic to ameliorate the range of actuation of the ship.

Two different propulsion techniques used in the ships Cornide de Saavedra (two diesel engines, variable propeller) and Vizconde de Eza (diesel-electric engines, fixed pitch propeller) are measured and compared as regard noise radiated to the water, and the acoustic signatures of both ships are determined according to ICES recommendations.

1. INTRODUCTION.

The estimations of abundance of pelagic populations by acoustic methods produce systematic and random errors that affect both to its precision and exactitude. One of the sources of error that is more difficult to measure is the influence of the research ship on the behavior of fishes. It has been demonstrated that fish react to the presence of the ships, and that the reactions affect to the estimations of abundance. According to the existing literature on this subject, that has been compiled by McLennan and Simmons (1992), the oceanographic ship ought to produce a minimum impact on the behavior of fishes, both during the acoustic prospecting at ten knots and during the fishing operations at four knots.

Consequently, a study is being made of the impact that the acoustic signature of the ship can produce on the estimations of the biomass of pelagic resources by means of acoustic methods, mainly by echo-integration.

To demonstrate that these methods applied by different oceanographic ships in the same area and time of the year present significant differences due to the differences in the acoustic signatures of both ships, the signatures have been measured previously in the same environmental conditions.

Where acoustic surveys are undertaken, in addition to avoid any disturbance of the natural distribution of the fish, it is necessary to ensure that the fish target strength distributions and echo-integrator results are free of bias due to high frequency noise. Here the propeller is the main source but the flow in pumps and piping, hull roughness and hull protrusions can also add significantly to the noise signature.

The propulsion power of vessels has continued to increase, it is now approximately twice than the used 25 years ago and such an increase produces consequently higher noise levels.

Individual noise signatures of some vessels have been examined with the purpose of describing the origins of radiated noise and relating them to engines, gearboxes, propellers, pumps, etc. Whenever possible, the characteristic noise spectrum of these items of machinery is demonstrated in terms of changes of the frequency and amplitude of the vessel signature. Some machinery configurations have the potential to produce higher noise levels than others but the extent of actual differences depends on many factors including the construction of the hull and particularly on the operational aspects of speed control. The latter effect is seen most clearly in the case of controllable pitch propellers (CPP's).

Despite wide variations in the use of individual machines there are two principal configurations: diesel /gearbox /CPP and Diesel-electric. With the first configuration it is normal to have an engine driving a gearbox with typically two speeds and the output shaft of the gearbox coupled to the propeller. The purpose of a controllable pitch propeller is to provide a smooth speed control for the vessel. From a mechanical and operational viewpoint this method of speed control works well, but it is clear from the evidence that it is most unsatisfactory when underwater radiated noise is considered. Diesel-electric installations have one or more diesel engines driving electrical generators which provide power for propulsion and other services. Some of the power from the generator is connected to the shaft of a fixed blade propeller. With modern technology the diesel-electric system has the potential to achieve much better noise reduction and is capable of meeting the levels that a fisheries research vessels might be expected to attain.

2. MEASUREMENT OF THE ACOUSTIC SIGNATURE OF THE OCEANOGRAPHIC SHIPS

The measurement of the acoustic signature of the ships B/O Cornide de Saavedra and Vizconde de Eza has been made according to the recommendations of the ICES in a way that they could be compared with the signatures of other oceanographic ships. The signature has been measured for both ships at the speed of acoustic survey (10 knots) and of trolling (4 knots). For the Vizconde de Eza, the measurements have been made in two different conditions of the transducer keel, extended and retracted. The campaign of measurement of acoustic signatures has been made from 19th to 21st of February 2002 at the Gulf of Cadiz, in the south of Spain.

The deep of the sea bottom of the measurement area (36.35 N, 6.42 W) is higher than 80 m, the sea state was with waves of less than half a meter. Using an auxiliary boat, a hydrophone Brüel&Kjaer 8104 was submerged to a depth of ten metres. The signal from the hydrophone was duly amplified by means of a Brüel&Kjaer 2635 amplifier and recorded in a Sony Dat PDR 1000, for later analysis and processing.

Both oceanographic ships made trajectories at four and ten knots, at distances of 50, 100 and 200 metres of the auxiliary boat, pass-byes to port and starboard sides. The distances boat-ship were measured by means of a GPS system (Figure 1).

From the corresponding recordings of each pass-by, a sample of a duration of one second has been digitised, when the ship was nearer to the hydrophone. The sampling period is 50 μs. This period allows a frequency analysis from 10 Hz to 10 kHz, with a bandwidth of 1 Hz, by means of a FFT analysis of the selected sample. In Figure 2 an example of temporal sample is presented, with its corresponding frequency spectrum in dB re. 1μPa. From the trajectories of the ships in each pass-by, it has been determined the minimum distance ship-hydrophone to make the correction for distance and refer the frequency spectra to one metre. Later on, the frequency spectra corresponding to the distances of 50, 100 and 200 m have been processed, and they have been obtained the acoustic signatures with a bandwidth of 1 Hz, and have been converted to a bandwidth of a third of octave (Figures 3 and 4).

The acoustic signatures are compared for the same conditions of speed for port and starboard sides of the two ships, and for the Vizconde de Eza with the keel down and retracted. The acoustic signatures for 4 and 10 knots are also compared.

3. RESULTS

There are not relevant differences between the noise radiated by the port and starboard sides of the ships for the whole analyzed frequency range. The noise radiated by the Vizconde de Eza, both with the keel down and retracted, increases significantly when the speed increases from 4 to 10 knots, mainly at the high frequency range.

It is important to notice a significant increase of the noise radiated by the Cornide de Saavedra when reducing the speed from 10 knots to 4 knots, probably due to the system of propulsion of the ship.

At the speed of 4 knots, the Cornide de Saavedra is 20 dB noisier than the Vizconde de Eza, for frequencies higher than 300 Hz. With the keel down, the level goes down another 5 dB at all frequencies (Figure 3). At 10 knots, the noise radiated by both ships is quite similar. The Cornide de Saavedra is 3 dB noisier than the Vizconde de Eza, for frequencies higher than 1000 Hz, but the reverse is true with the keel retracted: the noise is 5 dB higher between 50 and 300 Hz (Figure 4).

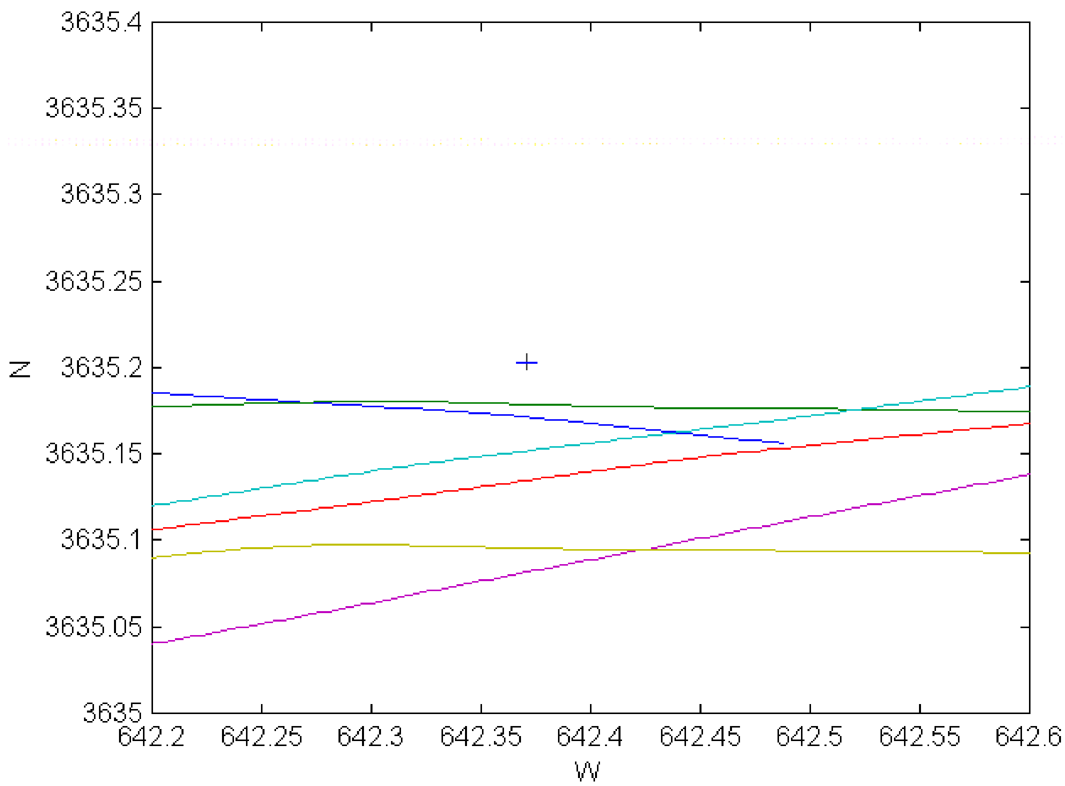

Figure 1.- Trajectories of the ship Cornide de Saavedra at 10 knots. Dark blue, port, 50 m. Dark green, starboard, 50 m. Red, port 100 m. Light blue, starboard, 100 m. Magenta, port, 200 m. Light green, starboard, 200 m.

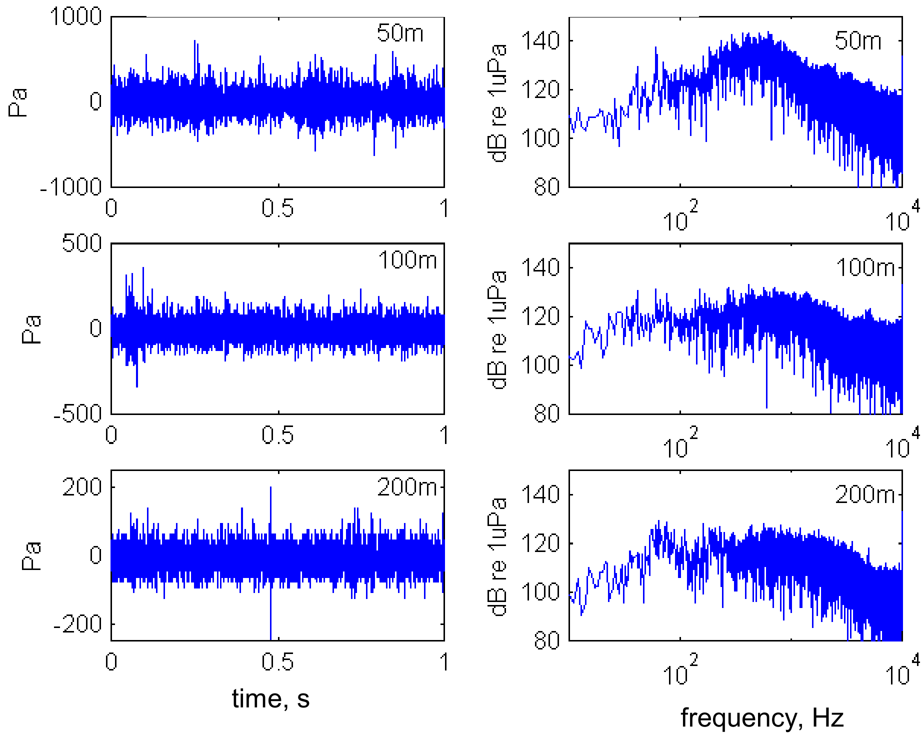

Figure 2.- Temporal sample, and frequency spectrum, in dB re. 1 μPa, of the noise radiated by the ship Cornide de Saavedra, 4 knots, port side.

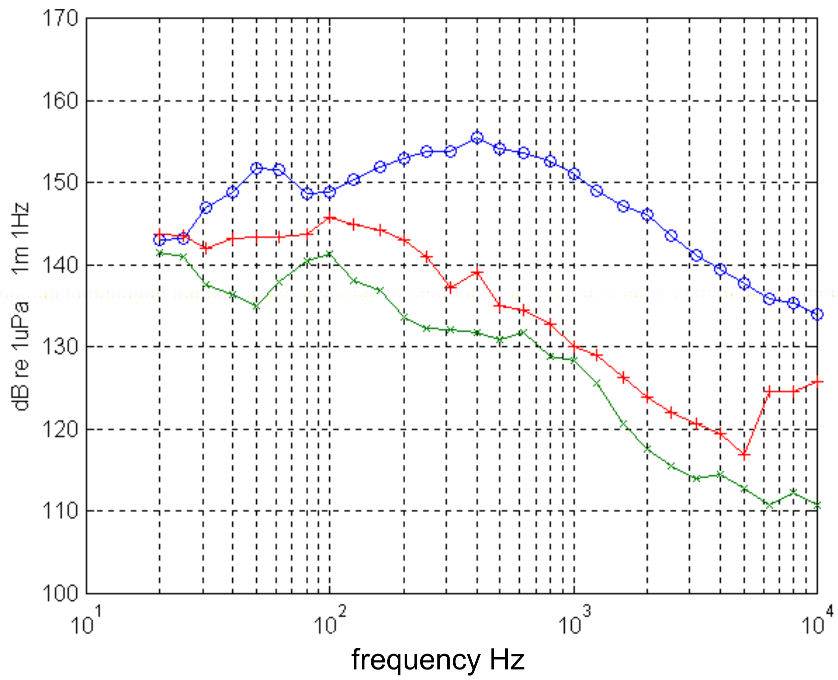

Figure 3.- Acoustic signature of the ships Cornide de Saavedra (blue); Vizconde de Eza with keel down (green); Vizconde de Eza, keel retracted (red). Speed 4 knots.

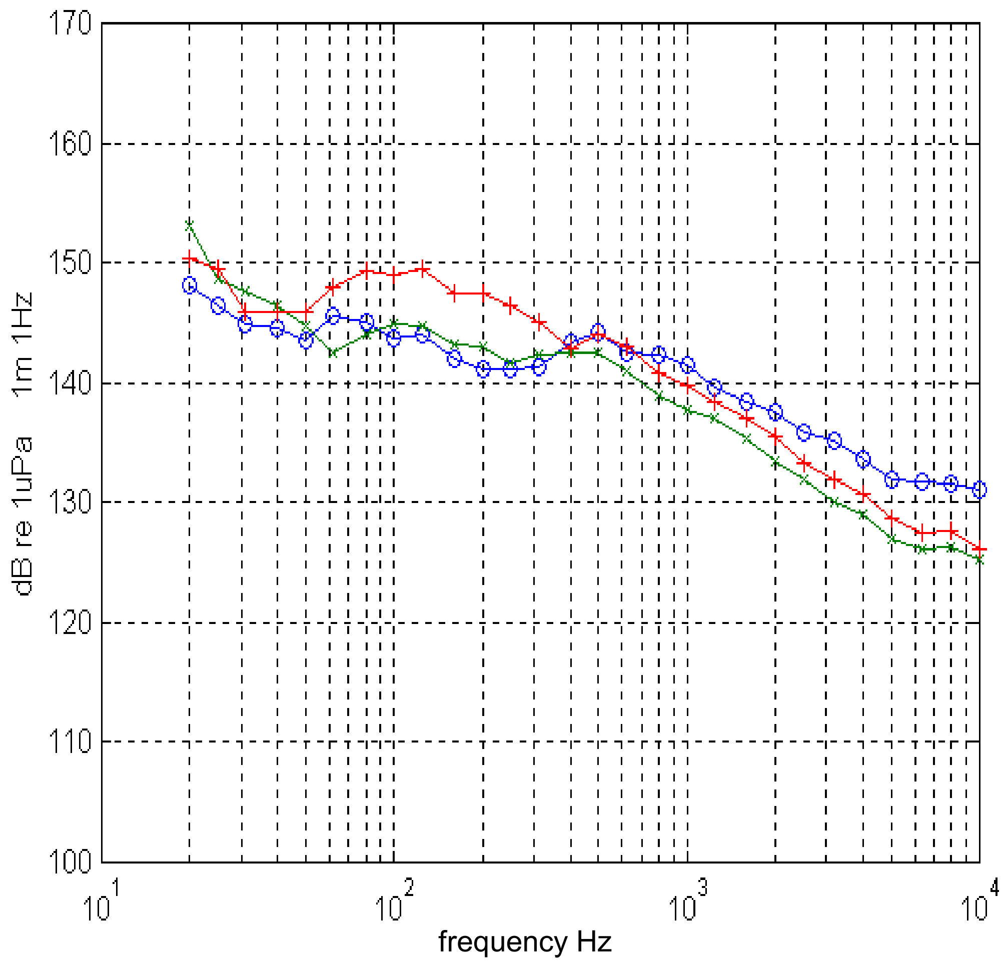

Figure 4.- Acoustic signature of the ships Cornide de Saavedra (blue); Vizconde de Eza with keel down (green); Vizconde de Eza, keel retracted (red). Speed 10 knots.

REFERENCES

MacLennan, D. N. and Simmonds, E. J.. Fisheries Acoustics. Chapman & Hall, Fish and Fisheries Series 5, 1992