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A SIMPLE STANDARDISATION OF OMNIDIRECTIONAL SONAR IN FISHERIES RESEARCH THROUGH FIELD CALIBRATION AND SAMPLING DATA

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The paper presents a method making a comparison of acoustic results on schools through the use of omnidirectional sonar (possible). The weakness of such sonar for fisheries acoustics is that there is no practical way to accurately calibrate them, due to the fact that they are not designed specifically for scientific research. The procedure employed is through the use in the field of a reference target allowing to compare the echoes from one beam to the other and to evaluate roughly the operational threshold for school identification. Some results from a calibration achieved on a SIMRAD SR240 in Venezuela, 1998, are detailed.

INTRODUCTION

Direct observation of fish schools at large scale has been commonly done since the 70s using vertical echo sounder and scanning sonar (Fernandes et al, 2000). The transformation of relative densities into absolute biomass requires an accurate calibration of the acoustic devices to be achieved. Such techniques have been standardised and simplified for vertical echo sounders with the use of standard targets (Foote, 1987). As far as horizontal sonar are concerned, these tools have rarely been calibrated, for several reasons, the principal being that they were mostly used for observing and counting fish schools, with no aim to measure the actual biomass of the schools. Nevertheless, nowadays omnidirectional sonar have become of wider use, and although they are not used for absolute biomass measurements, it is important to have a correct idea of their capabilities, in order to know the actual threshold applied on school observation. At present there is no published procedure for such evaluation. Moreover, as these devices are designed mostly for fishermen, there is practically no real information on the way the filters developed by the manufacturers are selecting the school echoes, and this must also be evaluated on the data of a survey.

1. MATERIAL AND METHODS

The sonar we used was a SIMRAD SR240 omnidirectional sonar, transmitting on 360° with 32 beams of 11.25° (horizontal) x12° (vertical) each. The frequency is 23.750 kHz and **the pulse duration** > 1 ms. The sonar was embarked aboard the R/V ANTEA (IRD, France), and the calibration was performed in the bay of Mochima, Eastern Venezuela, in March, 1998. Data acquisition was carried out through recorded video images of the sonar screen, according to Brehmer and Gerlotto (2000). The calibration is done using a second research vessel, R/V Hno Gines (Fundacion La Salle, Venezuela), 25 m stern trawler. The principle is to deploy a reference target aboard the Hno Gines, which circles around the ANTEA in order to have the target insonified successively by all the sonar beams. There is no information in literature on the ideal reference target for such a tool and frequency. Therefore the target selected was a cluster of 9 spheres (25 cm ∅ trawl bowls). In order to have an idea of the volume backscattering of this target, a portable dual beam echo sounder (Biosonics DT5000, 1997) was permanently set above the cluster. This allowed a check whether the global volume backscattering strength remained constant during the experiment. The global characteristics of the target were: size: 4 m; surface: 0.78 m²; volume: 0.5 m^3; Sv: -41.8 dB (at 129 kHz). Before insonifying the target, the self-testing procedure of the sonar which controls the system processor, the source level (SL, the voltage response (VR) and the noise (Simrad, 1992) was followed. Then our procedure consisted in setting the target at different distances and depth of all the beams. This series of values allows to build an empirical 3D directivity diagram. This requires first the sonar headings be controlled. The operation consists in adjusting the sonar beams with the vessel bearing. Once the target detected on the ahead beam of the sonar, the radar is used to adjust the bearing of the sonar. At a given distance, the target width must be smaller than the beam diameter (Misund, 1990). Then the beam pattern has to be measured according to the various sonar settings. This is obtained by moving the target in the 3 dimensions (controlled by the radar location of the R/V Gines for the horizontal dimensions, and the portable echo sounder for the vertical one) inside the beam. Once this series of operations is performed, the "calibration" will give two pieces of information:

- at current settings, the detection of the target within the sonar sampling volume; then this is repeated at the different usual settings; this last operation will give information on the shadow areas and limits of detection within each beam for a given hydrological structure of the water column. It allows also to test the actual effects of the sonar filters on a static target
- finally moving the target allows to "simulate" the movements of a fish school within the whole sampling volume. This can be done either along a single beam or crossing several beams. Finally this dynamic calibration can be performed using two separate targets of different dimensions, in order to test the actual dimension of the pulse duration (which may vary depending on the setting: in single or modulated frequency); and evaluate when the filtering makes the smallest target disappearing.

2. RESULTS

During our experiment, the self-testing gave nominal results for all the sonar characteristics, although we could not establish the complete 3D directivity diagram due to a strong thermocline which produced important blind zones. A first important point was noted: a shift on the sonar heading, 23° starboard. This point was expected, as we observed during the former survey that the schools seemed to move across the surveyed circle following the same general pattern, i.e. crossing the area with this 23° angle compared to the route of the vessel. The other main results were the following:

- importance of the emitted energy: the target is best recorded when using high voltage settings;

- the apparent along beam size dimension (Lw_a) increases with the TX power (table 1)
- The same phenomenon occurs with the variation of the reflectivity index according to the TX power (the target remaining at the same distance)
- TVG did not give very consistent results: no variation of IR whatever the value (TVG 30 log R), while Lw_a seems to increase with R
- The "continuous wave mode" gives the best size estimation, according to the sonar setting (table 1, pulse form test).
- The FM auto mode gives a corrected value equal to 0 due to the long pulse duration.

Table 1: Test results: an average of 4 successive observations on a same target. IR: index of reflectivity (code 1, 2 &3). Lw_a is the apparent along beam dimension on the sonar display; $Lw_c=Lw_a-C\tau/2$ (Misund, 1990) according to the local celerity and the pulse length. Sonar setting: range: 400m, pulse form: *fm auto*, (τ=16ms); filter[1] position: *RCG* on *strong* position, *PP* in *medium* position and the *ACG* off.

TX[2] power	20V	60V	130V	**TVG**	R=80	R=150	R=300	R=700	R=1600	**Pulse form**	Cw s 2ms	Cw n 4ms	Cw l 8ms	Fm 4 16ms
Lw_a	8.5	8.5	9.9	Lw_a	3.9	2.8	2.8	7.5	6.4	Lw_a	3.6	4.7	4.5	3.6
Lw_c	0	0	0	Lw_c	0	0	0	0	0	Lw_c	2.1	1.7	0	0
IR	1.5	1.5	2	IR	1	1	1	1	1	IR	1.5	2	1	1

In order to use stronger targets, we used some natural permanent targets (anchored vessels) easily detected on sonar at different scales for the range test (fig.1). The linear regression of the apparent along beam dimension shows a proportional decrease of the target size according to the sonar range for the distance to the boat between 152 to 399m. The IR value seems to increase with both the sonar range and the pulse length. As we observe that the target speed increases significantly as the target accelerates we may assume that the target speed is under evaluated or the given values of the speed of the target vessel is erroneous

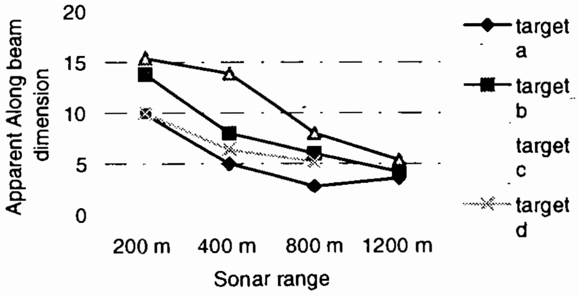

Figure 1: Variation of the sonar range between 200 to 1600m on 4 anchored vessels; the result is an average of 4 values of the along beam dimension in each case. The small table below expresses results of the linear regression coefficient R^2 for each target at a different sonar range.

Target	A	B	C	D
R^2	0.60	0.91	0.95	0.92

3. DISCUSSION AND CONCLUSION

The next application of the methodology described will be carried out in open water, using a larger target. Another improvement would be to properly define an adequate target, calculated according to each sonar type. Ideally the target must be homogenous and omnidirectional (spherical shape), and should be included inside the insonified volume of a beam (which may limit its use at short distance from the transducer). The *Fm* mode selects

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[1] Filter: RCG: reverberation gain control; PP: ping to ping analysis; ACG: automatic gain control, (Simrad, 1992)

[2] Active transmission power, output voltage measured on voltmeter in the transceiver unit.

automatically the optimal number of frequencies and uses high pulse length (16 or 64 ms) t enhance target detection. The experience acquired is important for the use of this sonar which necessitates a specific operator (Diner, 1995). It seems important to use the full powe and reduce if necessary the gain in order to reduce the received noise level. The range tes gives good results, and it is possible to use the sonar at different ranges during a same tracking. To control the target size we have to work in "continuous wave" mode. The evaluation of instantaneous speed seems to be good but needs more tests. It was impossible to produce the 2D diagram of directivity and all the tests described, due to the local condition inside the bay. We observed a strong variability for the same target of the along beam dimension and IR due to its position inside the beam (at the -3dB point). In order to minimise the bias we suggest to first use its average value assuming the target be spherical. The choice of the optimal setting depends of the topic of research, the size of school(s) studied and their distance to the nearest neighbour. The most convenient protocol of data collection should be the following: graphics sonar format (at least: 800*600 pixels/8-bits); units: meter, degree and second; the *Cw* dimension can be used if the audio beam channel is narrow (≤ 5°); with θ = 11°.5 ± 0.5°, we only use the maximum along beam dimension observed; filters: never use the *ACG*, and prefer the *PP* (medium to strong) and *RCG* filter (medium to strong) in shallow water.

Target	Date	Time	Cw_a	Cw_c	Lw_a	Lw_c	IR	Range	τ	Celerity	(X;Y)	R	B	I
Value	Julian day	=(hh*360)+(mm*60)+ss	Measured	= Cwa -2R tan B/2	Measured	= Lwa – (Cτ/2)	Observed	Observed	Observed	=1449.2+3.5T+(S – 35)+0.18D	Measured	Measured	Observed	Tan(tilt)*R

Table 2: The graphics sonar format units: meter, degree and second. Misund O.A. 1990 gives Cw_c Lw_c ,(X; Y) school and transducer positions, S salinity (‰), T temperature (Celsius), D beam depth, R distance target-transducer, B audio beam channel and τ pulse length.

Once calibrated this type of sonar provides a varied source of information. The future omnidirectional sonar needs Split beam technology on each beam for a better calibration in free water and for use in fisheries research (trace tracking). At present we need a correction factor for each beam in post processing, for a biomass estimate. The tool of analysis exists already through *Infobancs 2.0* (Brehmer P., Gerlotto F., 2000) and the new video format for data acquisition (*Digital Video*) will bring us much better accuracy.

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