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A methodology for in situ measurement of mean target strength in small schools.

by

Pierre Fréon & François Gerlotto
Pôle de Recherche Océanologique et Halieutique Caraïbe
ORTOM, BP 81, 97256 Fort-de-France Cédex,
Martinique (French W.I.)

I. INTRODUCTION

Different methods of TS measurement have been already performed on single fish (caged, tethered or wild in situ) or on number of live fish in a cage (Johannesson and Mitson, 1983; Foote, 1987). Each method presents its own advantage and limitations. The three main problems to solve are:

(1) to perform the measure on fish behaving as close as possible from their natural behaviour and physiological condition,

(2) to take into account the effect of the transducer beam pattern,

(3) to take account of the bias introduced by high fish density (acoustic shadowing or re-radiation) when school echoes are integrated.

During the last decade the scientific effort was oriented toward the resolution of mostly one of these three problems at the same time, by measuring in situ individual wild fish when distributed in low density (dual beam or split beam) or by measuring fish in a small cage. Olsen (1986) intended to estimate the sound attenuation under a large herring school, but as far as we know, no attempt of TS measurement as been done on wild school, although this seems possible when some particular conditions are satisfied. In this case, the above mentionned three problems are all overcome.

II. EQUIPMENT

An EYM Simrad sounder with a wide beam transducer (22°) has been used, connected to an Agenor (IFREMER/ORSTOM) digital echo-integrator and to a tape recorder (during the future experiment, a analogic-digital converter will be used in order to reduce the possible biases introduced by analogic tape recording).

A wide angle camera was connected to a video tape recorder equipped with a precise revolution counter and allowing a performant slow motion and frame by frame play-back. A microphone was also connected for comments and for checking the synchronisation between tape and video recording. A 6 meter tube ended by a one meter graduated bar was used for calibrating the size of the video pictures according to the depth and to the monitor screen size (fig. 1).

All this equipment was installed on an instrumented raft, providing a support for the transducer and the camera more stable and shallower than a boat in the coastal area where the experiment was carried on.

Some observations have been done on completely wild schools and others on small schools enclosed in a large net (purse-seine) used as a mesocosm and providing an apparent natural behaviour of the school (see fig. 2 and Fréon & Gerlotto, this meeting).

III. METHODOLOGY

Using Johannesson & Mitson's (1983) notation, where S_v is the mean volume back-scattering strength, we get:

$$S_v = 10 \log \rho_v + TS \text{ dB} \qquad (1)$$

where TS is the mean target-strength and ρ_v the mean density expressed in number of fish per cubic meter. If some conditions are satisfied, the mean density ρ_v of a thin fish layer can be estimated using a sounder and a camera. This can be done considering the volume V of the truncated cone delimited on the one hand by the camera field of view and on the other hand by the upper and lower limits of the layer (d_1 and d_2), obtained from the sounder (fig. 1). So we get:

$$h = d_2 - d_1$$
$$r = tg\ \theta_1\ d_1$$
$$R = tg\ \theta_1\ d_2$$

$$V = \pi \frac{h}{3} (R^2 + r^2 + Rr)$$

If the layer density is likely homogeneous and presents a fairly constant thickness (as on photo 1 and 2), and if the mean depth of this layer is rather constant during a few seconds, then some sampled wiews can be used for estimating the mean density inside the volume V. For instance on a stable 30 second sequence the sampling frequency could be of one frame each second. The frame by frame system of the video recorder can be used, or a digitalized picture can be analysed on a computer.

The species composition and the mean fish length can be estimated either by fishing or by using the video for measuring the fish on the monitor and calculating the rising factor from the calibration results and according to the mean depth given by the sounder. If the layer thickness is too high and introduces a large variability of the apparent lengths measured on the screen, then only the largest fish can be measured, considering that they are located in the upper part of the layer (such a method supposes a narrow distribution of the body lengths and tilt angles inside the schools). Other approaches can be developped using stereo camera or a second video camera (or photo camera) with a large focal lens providing a narrow depth of field.

In this last case, a narrow interval of depth can be sampled inside the layer by measuring only the fish presenting a good resolution. The calibration of this second camera must be achieved under identical conditions to those taking place during the experiment on the school (turbidity, light intensity and direction), using the same graduated tube or better a died fish. This will provide both the precise mean depth of sampling and its range.

If the transducer and the camera lens are properly choosen in order to have the angle θ of the lens widely greater than the mean angle of the transducer beam at -5 dB for instance, therefore the S_v values can be assumed to be representative of the mean acoustic response of the transducer for a given depth, when the layer is observed on the whole screen surface.

Some experiments were conducted after fixing the camera and the transducer on the raft, but others were realized with these devices fixed on the bottom and oriented toward the surface. According to the depth of the layer and to the water transparency, one or the other method is suitable. If the fish directivity diagram is supposed to present a vertical axis of symetry -as usually admitted- then the results must be consistent. Observations from the bottom present three advantages: first the camera and the transducer are absolutely stable and provide less variable data, second the pictures are perfectly contrasted ("shadow show") and third there is absolutely no influence of the equipment on the fish behaviour.

Knowing S_v and ρ_v, TS can be easily calculated.

IV. DISCUSSION

The methodology is quite similar to the one applied when using a large cage including completely the main beam. Indeed, the lateral limits of the camera field of view can be compared to the vertical walls of the cage, and the natural upper and lower limits of the layer can be compared to the top and bottom of the cage. The two main differences between the two approaches are first the complitely natural behaviour in our experiment and second a more random distribution of the fish with respect to the transducer beam pattern.

This methodological approach cannot be applied to any species and biotopes. It is essentially adapted to some coastal pelagic species (or small demersal species living in schools), living in transparent water. The following conditions must be satisfied:

(1) distance between the fish layer (or school) and the set camera-transducer inside a 2 to 12 meter interval, i.e. the layer must be close enough to the bottom or to the surface,

(2) water transparency enabling one to count fish using the camera,

(3) layer or school not too thick or too dense

(4) homogeneous density of the fish layer, without "vacuoles", and presenting a rather stable thickness,

(5) if the camera must be used from the surface, shallow ground and homogeneous sea bed color providing a good contrast with the fish.

Further experiments carried on inside the enclosure on the same school should provide estimations of the measument variability and indication on the repetitivity of the behaviour influence on the TS. For instance, TS measurement could be done at different levels of polarization of the school (using artificial stress) or at different density or thickness.

REFERENCES

Foote, K.G. 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. (in press).

Johannesson K.A. & Mitson, R.B. 1983. Fisheries acoustics: a practical manuel for aquatic biomass estimation. FAO Fish. Tech. Paper 240: 249 p.

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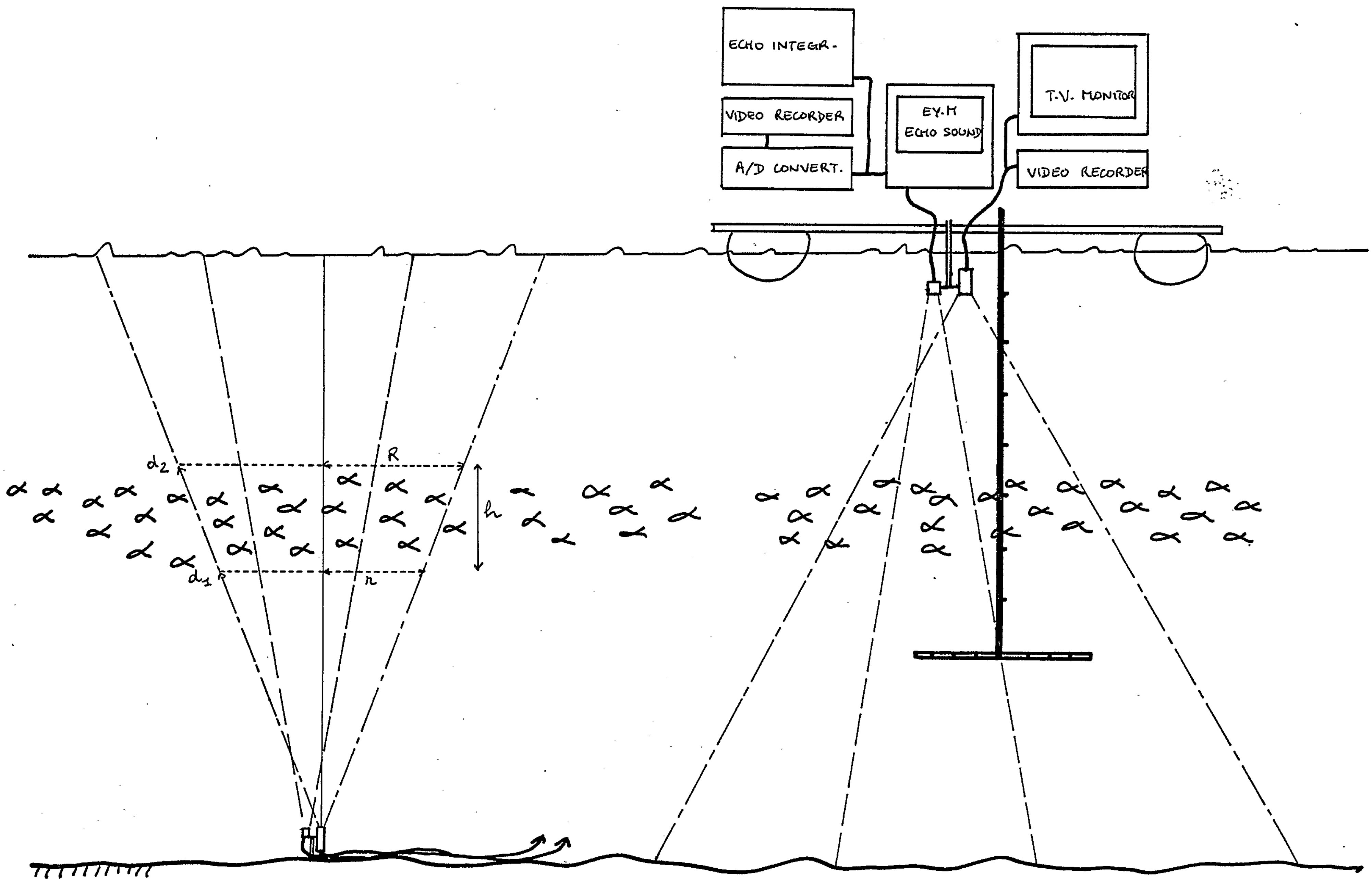
FIGURES & PHOTOS

Fig. 1. Field equipement for _in situ_ measurement of TS

Photo 2. Vertical view of a of _Harengula jaguana_ layer.

Photo 2. Lateral view of a of _Harengula jaguana_ layer.



ECHO INTEGR.
VIDEO RECORDER
A/D CONVERT.
EY-M
ECHO SOUND
T.V. MONITOR
VIDEO RECORDER
R
d2
h
d1
r

Fig. 1