TARGET STRENGTH MEASUREMENTS ON THREE PELAGIC FISHES FROM THE JAVA SEA

P. Cotel and Petit D.

PELFISH PROJECT, c/o ORSTOM, Kemang Indah Kav. L2, Jalan Kemang Selatan I/2, Jakarta 12730, Indonesia.

Using acoustics for biomass evaluation, the back scattering cross section of species has to be determinated to convert the data into weighted values. During the cruises of EU Project "Java Sea Pelagic Fishery", TS measurements on three pelagic fishes of economic importance : *Decapterus russelli, Selar crumenophthalmus, Rastrelliger kanagurta* were carried out, using a Biosonics dual beam echosounder at 120KHZ. The observations on single or multiple targets in a cage, revealed a large dispersion of the responses, even in the same experiment. These results are discussed and compared with Johannesson's (Anonymous, 1984) in the same area.

Key words : Java Sea, Pelagic fishes, Acoustics, Methodology, Target strength.

Introduction

With the calibration of acoustic equipment, reflection index measuring of live fish constitutes the first stage in the evaluation of abundance. This operation should allow the adjustment of the threshold on the echo voltages which are to be taken into account; it should also allow the calculation of a conversion constant of integrated voltages during prospection of biomass measuring. The following observations were made during the "Java Sea Pelagic Fishery Assessment" Project.

Materials and Method

Three series of measuring have been made during the season when pelagic fish abound in the Java Sea : November 91, October and December 92. The success of these experiments is dependent upon strict environmental conditions : the location has to be deep and sheltered from the wind and currents ; it must moreover be close to a fishing zone. Only two places in the Java Sea were found to be acceptable : Bawean Island and Matasiri Island ; the former, 17 meters depth, in a bay, was the best.

The measurements were made with a dual beam Biosonics echo-sounder (7° narrow and 18° wide circular beams). The acoustic characteristics of the equipment were controlled previously on a standard tungstene ball with a -41dB reflection index. Characteristics and adjustments throughout the measurements can be found in the Table 1.

Table 1. Sounder characteristics

Transmitter Source Level : 222.54 dB /µPa /m
Narrow beam Receiving Sensitivity: -173.13 dB/V/µPa
Wide beam Receiving Sensitivity : -172.17 dB/V/µPa
Pulse Duration : 0.4 ms
Ping Rate : 3 / second
Threshold : 100 mV
TVG : 40 Log R + 2 αR α = 34.7 dB/km R = 125m

In order to keep the fish in the acoustic beam, the latter is introduced into a conical cage specially built in order not to be disturbed by the reflecting contribution of the lateral surface. The transducer is an integral part of this cage (Fig. 1). In this way the transmitted signal is not attenuated by the net, the cage is sufficiently spacious to permit the movement of the fish and to record the echo without interference. The measurements were taken from three pelagic species, among the most exploited in the Java Sea : *Decapterus russelli, Selar crumenophtalmus* and *Rastrelliger kanagurta*. The three species have a swimbladder. The fish were introduced into the cage in sets of 1, 2, 4 or 6 ; the cage was then submerged. Reverberation measurements were taken both night and day.

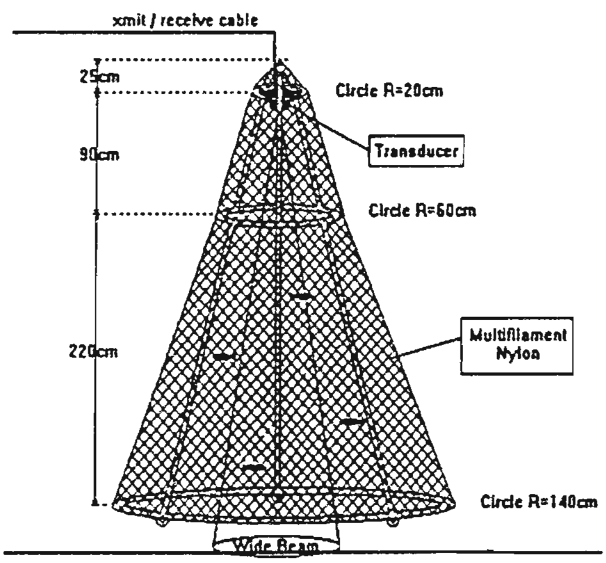

Fig. 1. The live fish calibration cage.

Results

Dispersal of Measurements

The most significant aspect from these experiments is the dispersion of the values that considerably mask the existence of a relation between the reverberation index and the size of targets, on the short interval of length (11 to 17 cm). Figure 2 represents the distribution of Target Strength measurements of *Selar* between 12 cm and 17 cm (fork length) ; the same dispersion can be observed with *Decapterus* and we saw no notable decline in this dispersion according to the number of measurements.

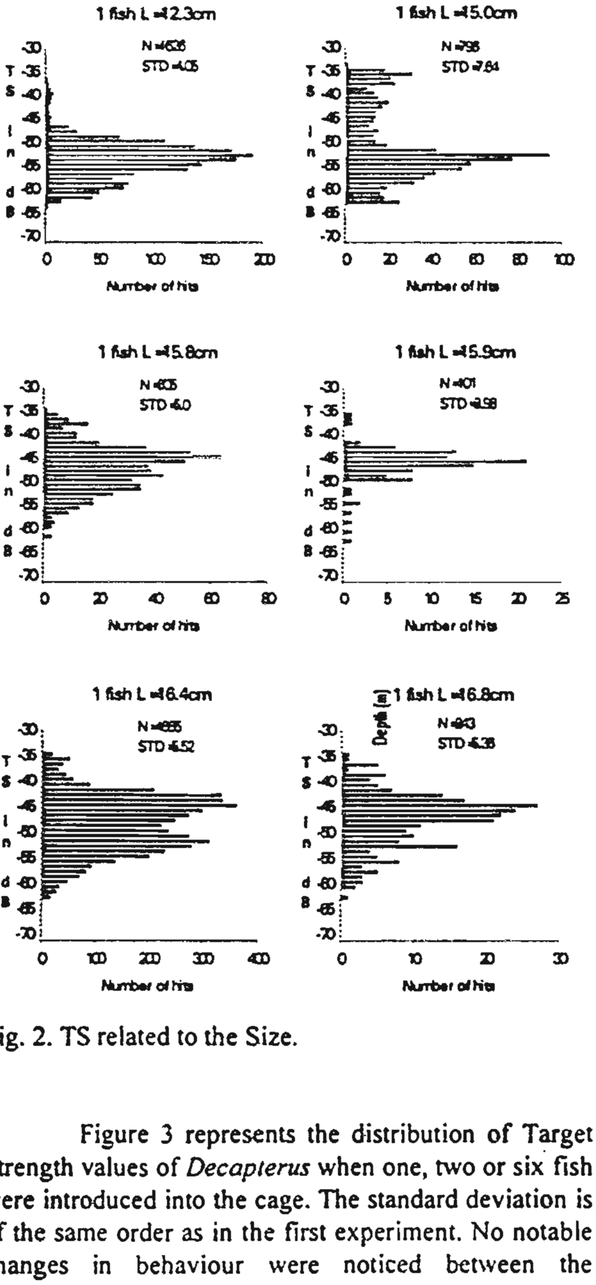

Fig. 2. TS related to the Size.

Figure 3 represents the distribution of Target Strength values of *Decapterus* when one, two or six fish were introduced into the cage. The standard deviation is of the same order as in the first experiment. No notable changes in behaviour were noticed between the observation on one fish and on several : the "group effect" does not seem to influence measurements.

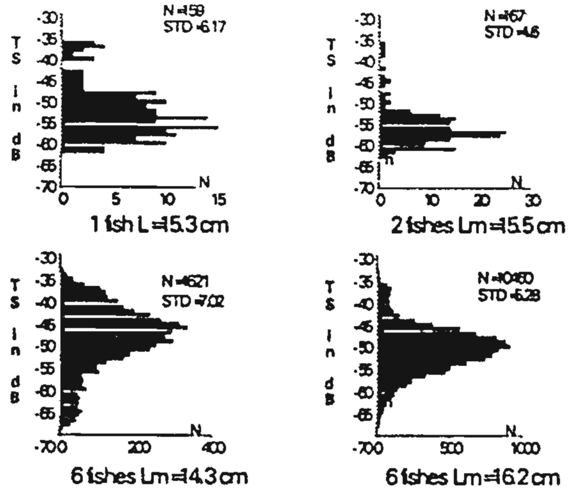

Fig. 3. TS related to the number of fish.

"Swimming Activity" Effects

The influence of the position a fish takes in the sonar beam on its acoustic response is known (Love, 1971 and 1977 ; Nakken and Olsen, 1977). The acoustic response is the strongest laterally. In dorsal detection the reverberation index can vary to more than 10 dB according to the fish tilting (in less than 15°). In classic prospection conditions, such variations can be attributed to different species as well as the inclination of the same species if we do not have simultaneous visual information. Observations carried out on the isolated fish in the cage gives us knowledge about the vertical location and the acoustic response. By using the results of an experiment on *Selar*, we put the reverberation index and the vertical positioning of the fish in relation (Fig. 4a).

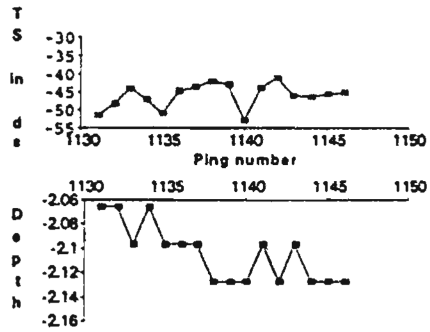

Fig. 4a. TS during low swimming activity.

From ping to ping, the position slightly changes and suggest very low swimming activity. The dispersion of index values is slight as well. On the contrary, in the same series of values, while selecting events where the fish shows a significant vertical movement, the corresponding index values show a strong dispersion (Fig. 4b). Owing to an intense swimming activity, the fish enters the sonar beam in different positions which leads to strong index dispersal.

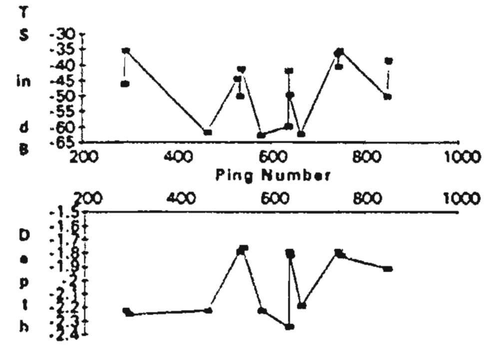

Fig. 4b. TS during high swimming activity.

Influence of External Factors

Under normal acoustic prospection conditions, the influence and effects of disruptive external factors is generally difficult to bring to light. The state of being confined in a cage can in itself have a considerable effect. We assume that since the length of time necessary for measurements is short, this effect is only slightly disruptive[1]. The animal gets used to its environment and the noise.

The effect of light during prospection was noted in some experiments (Levenez *et al.*, 1987 ; Gerlotto *et al.*, 1990) and the authors consider that it tends to polarize the fish more than generate an escape reaction. In the region, light is used to gather the fish together which makes it easier to catch them.

Figure 5 shows the reactions of one group of g. *Selar* to the light. The experiments took place at about 10 PM. In the first experiment a 400 watt lamp attached to the rail, lit the cage which was submerged at about 3 meters. In the second experiment, a 1000 watt lamparo was used. It was placed at 2 m under the cage ; in the third, it was pitch-black.

In the first two experiments, the fish showed from the position they took in the cage, that they tend to avoid the light and that swimming activity is reduced. When darkness is back, the echoes are dispersed in the cage space; swimming activity is increased. Even though the experiment was brief, it shows that light, in provoking a reaction, can bias index measurements.

[1] Unless behaviour is visibly such that measurements can not be taken : permanence out of the acoustic beam or permanently random activity.

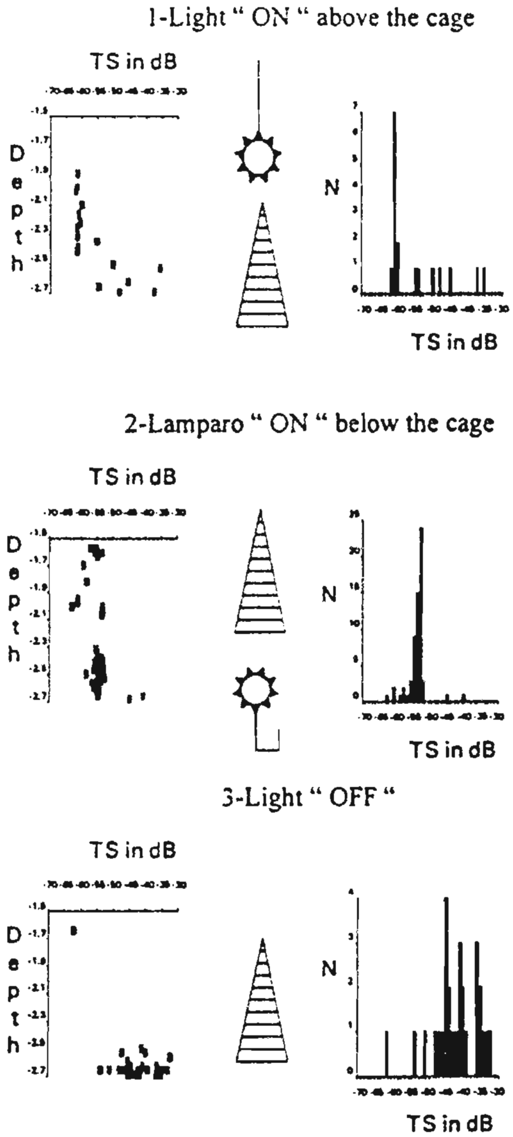

Fig. 5. Light Influence.

Adjusting the Equipment

Reverberation index measures require first that the acoustic characteristics to be known exactly. In the case of dual beam sounder, one part of these controls (source level and receiving sensitivity) is facilitated by the use of a tungstene ball as the standard target. However, the choice of electric level of the signals that are taken into account for index measurements is up to the operator. Use of a threshold that is too high risks suppressing the low reverberation values, truncating the distribution histograms.

Recorded with a 100 mv threshold, certain measurement series were played back with a 300 mv threshold. Table 2 summarizes the results and shows that the elimination of low values has a more or less significant effect according to the average index value and the dispersion. In our experiments, distribution histograms of index values are not shortened in respect of the weak values, it indicates that the chosen threshold (100 mv) was correct, taking into account the acoustic performance of the equipment.

Table 2. Index values related to the Threshold

SPECIES	LENGTH cm	INDEX values Threshold 100mV	Threshold 300mV
	12.5	-47.7 dB	-46.9 dB
	14.2	-47.5 dB	-46.4 dB
	14.3	-44.5 dB	-43.8 dB
Decapterus	15.3	-47.4 dB	-42.3 dB
	15.5	-51.4 dB	-42 dB
	15.7	-48 dB	-45 dB
	16.2	-47.7 dB	-47.1 dB
	12.3	-51.3 dB	-47 dB
	15	-43.6 dB	-39.5 dB
Selar	15.8	-44.2 dB	-42.8 dB
	15.9	-44.7 dB	-43.9 dB
	16.4	-44.9 dB	-42.7 dB
	16.8	-44.4 dB	-42.8 dB

Among the series of observations, we chose, as the most likely, the average reverberation index values in experiments where several animals were present and where the targets showed a fairly homogeneous distribution in the space of the cage.

The average values observed are :

D. russelli : TS = - 47.7 dB (Lf = 16 cm)

S. crumenophtalmus : TS = - 44.9 dB (Lf = 16 cm)

R. kanagurta : TS= -50 dB (Lf = 11 cm) but this value concerns a small number of values.

Conclusion

Reverberation index measurements are necessary for acoustics to define the conversion constant of reverberation measurements on biomass. In the past, these measurements were made on known quantities of fish introduced into a cage. This relatively simple method was not without risk : imprecision about the space really occupied by the fish, handling important quantities, incidence on measurements of minimal occupation space acting by means of behaviour (Foote, 1980a), death, possible multiple reverberations or shadow effect, besides reverberation on the surfaces of the cage of which the importance was only approximated (variable in time).

The development of new equipment (dual beam or split beam) and the computerization of signal data processing have allowed the use of a semi-automatic system of measurement and the development of software data processing. The fact remains, nevertheless that the operator should always take measurements with calibrated equipment.

The behaviour plays a very important role. That is the reason why one try to measure the reverberation index in a natural environment : in this way we attempt to avoid the interference of uncontrollable behavioural reactions produced by confinement in a cage.

Except the remaining exceptional situations, measurements "in situ" without simultaneous visual control cannot guarantee a value corresponding to a particular size known species. According to the catches in the Java Sea, five dominant species live together ; an imprecise knowledge of their geographical habitat and behaviour does not allow us to attribute the measurements to a given species.

On the other hand, in the calculation of the weight conversion constant we tended to use an index value which was close to the maximal response : the latter was considered to be the one produced by the fish in a normal position in the acoustic beam[2]. For a dozen years, one have tried to associate simultaneous orientation measurements of the target (Foote, 1980b) in order to calculate an index according to the most probable directivity of the fish. In situ, these kinds of observations are obviously rare, given the slight chance of encountering favorable conditions and the difficulty of getting the logistics. Very recently, observations on herring (Hamre and Dommasne, 1994) showed that in the reproductive phase, the reverberation index would be more low, in this specific case.

The choice of an index value should then be defined according to the predicated use (Foote, 1987). In our case, we tried to define an index destined for weight evaluations on "classical" prospections. To reduce a possible effect of being confined in a cage or isolated behaviour, it is recommended to increase the observations made up of a large number of measurements, the procedure aims to obtain an average index value corresponding to the most frequent position. Our observations show that optimal response values are found to be far away from the mode or the average, which indicates that the most favorable for a strong echo is not on average the usual position of the fish. In the Java Sea, shoals are not numerous; the fish are scattered. The nycthemeral density variations are strong; they suggest important vertical movements throughout the diurnal cycle. The behaviour observed in the cage, where the fish sustains considerable swimming action, does not seem to contradict the distribution and vertical movements observed in situ.

[2] Using a great quantity of encaged fish, we tried to make sure that the fish "turned", having then a behaviour close to the one observed in a natural environment while the fish is in shoal.

Until now, the great majority of index measurements concern the species of the North Atlantic stocks with sizes that greatly exceed the tropical pelagic ones. In operating on caged fish (measurements in 20 log function) Johannesson (Anonymous, 1984) has calculated - 45 dB on the same or related, species (*D. russelli* or *D. kuroides*). at the same frequency. Other experiments are still necessary to complete the first results.

References

Anonymous. 1984. Report on 1981-1983 Acoustic Fishery Resources Surveys in Southern Part of South Chine Sea with Special Reference to the Waters Aroud Natuna, Anambas, Serasan and Tambalan Islands groups. CIDA/FAO Indonesian Fisheries Development Project GCP/INS/056/CAN, Draft Report, 121p.

Foote, K.G. 1980a. Effect of Fish Behaviour on Echo energy : the Need for Measurements of Orientation Distributions. J. Cons. Int. Exp. Mer., 39 (2) : 93-201.

Foote, K.G. 1980b. Averaging of Fish Target Strength Functions. J. Acoust. Soc. Am., 67 (2) : 504-514.

Foote, K.G. 1987. Fish Target Strength for Use in Echointegration Surveys. J. Acoust. Soc. Am., 82 (3) : 981-987.

Gerlotto, F., D. Petit and P. Freon. 1990. Influence of the Light of a Survey Vessel on TS Distribution. CIEM/ICES Rostok, 10p.

Hamre, J. and A. Dommasne. 1994. Test Experiments of Target Strength of Herring by Comparing Density Indices Obtained by Acoustic Method and Purse Seine Catches. ICES, 9p.

Levenez, J.J., F. Gerlotto and D. Petit. 1987. Reaction of Tropical Coastal Pelagic Species to Artificial Lighting and Implications for the Assessment of Abundance by Echointegration. Rapp. P.V. Reun. Cons. Int. Expl. Mer, 189 : 128-134.

Love, R.K. 1971. Measurements of Fish Target Strength. A review. Fish. Bull. 69 (4) : 703-715.

Love, R.K. 1977. Target Strength of an Individual Fish at any Aspect. J. Acoust. Soc. Am., 62 (6) : 1397-1403.

Nakken, O. and K. Olsen. 1977. Target Strength Measurements of Fish. Rapp. P.V. Reun. Cons. Int. Expl. Mer, 170 : 52-69.

Cotel P., Petit Didier. (1996).

Target strength measurements on three pelagic fishes from the Java sea.

In : Collected reprints on the pelfish communications given to the fourth asian fisheries forum, 16-20 october 1995, Beijing. Djakarta : Agency for Agricultural Research and Development, (25), 5-9.

(Scientific and Technical Document ; 25). Asian Fisheries Forum, 4., Beijing (CHN), 1995/10/16-20.