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INFLUENCE OF THE LIGHT OF A SURVEY VESSEL ON TS DISTRIBUTION

(Influence de l'éclairage d'un navire de recherches en prospection acoustique sur la distribution des TS)

by

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RESUME

Des mesures d'écho-intégration et de TS "in situ" effectuées de nuit à l'aide d'un sondeur à faisceaux concentriques ont permis de vérifier l'effet de l'éclairement d'un navire de prospection sur les distributions bathymétriques des poissons. Deux résultats principaux ont été obtenus:

- les poissons des couches supérieures, contrairement à ce qu'avaient montré d'autres expériences dans la même zone, n'ont pas plongé lors des périodes éclairées, mais ont en partie évité latéralement le bateau, l'importance de cet évitement étant apparemment à relier à la taille et/ou à l'espèce des poissons;

- si l'on ne tient pas compte de la disparition des cibles les plus importantes, les niveaux de réflectivité moyens n'ont pas varié entre périodes obscures et éclairées, ce qui confirmerait l'hypothèse que les poissons sont polarisés par le bruit d'un navire et se trouvent généralement en position horizontale lors de son passage.

ABSTRACT

Some "in situ" measurements performed with a "dual-beam" echo sounder by night have permitted to evaluate the influence of the light of a boat on the inclination and avoidance of fish. Coupled with echo integration data, the results lead to the two following conclusions:

- the fish of the upper layers, contrarily to former experiments,

did not dive vertically when the boat passed over them, but tended to avoid laterally her route, the avoidance reaction being apparently in relation to the length and/or the species of the fish;

- when not taking into account the disappearance of the biggest targets, the mean backscattering cross section did not vary significantly whether the ship light was switched on or off. This phenomenon confirms the hypothesis that the fish are polarized horizontally by the noise before the ship overpasses them.

INTRODUCTION

Some former observations of the behaviour of the fish (LEVENEZ et al., 1987) showed two rather contradictory phenomena:

- the fish reacts very strongly to the light of a survey vessel by a neat diving behaviour, as shown in fig. 1.

- in spite of this avoidance reaction, the global density did not vary: the gravity centre of the biomass may change, but considering the total water column, it appeared clearly that all the biomass remained present.

These observations lead to the following hypothesis: the fish are probably polarized in horizontal position by the noise of the ship (warning situation), a rather long time before she passes upon them, and is insonified in this position; in this condition, if the echo sounder is using a TVG function, the depth of the gravity centre has no influence on the density evaluation, and therefore the actual condition of lighting (and noise) of the ship has no effect on density estimation. Another consequence of this fact is that the TS data of the fish would be similar by day and by night, the tilt angle of the fish depending probably on the noise of the ship (and its initial depth) and not on its natural behaviour.

We tried to test such an hypothesis using TS measurements on the fish "in situ". The results of these observations are presented in this work.

1. MATERIAL AND METHODS

1.1. Description of the survey methodology

The area of the study was the northern part of the gulf of Cariaco (eastern Venezuela), where some important sardine (Sardinella aurita) concentrations were found during a previous general survey (fig. 2). The experimental survey were performed using zig-zag transects. A 500 W light was fixed above the towed body of the transducer on the left side of the vessel, and alternately switched on and off every 6 mn, using the same experiment protocole as was used in a former experiment (LEVENEZ et al., 1987). The speed of the survey was around 5 knots, which fitted in the range of that of the above mentioned experiment. During the survey TS values were measured and processed by 6 mn ESDUs, as well as echo integration evaluations. The weather was cloudy, but the full moon was visible from time to time. The experiment took place from 8:00 pm to 11:45 pm.

1.2. TS Measurements

We used a dual beam echosounder type BioSonics 102, 120 kHz, aboard the R/V André Nizery (25 m stern trawler). The settings of the sounder are presented in table 1.

Receiving sensibility (cal. range 40 log R) :		-173.54
Source level :		221.63 dB
Threshold large beam :		100 mV rms
narrow beam :		50 mV rms
Selection criteria for individual targets		
- 6 dB :	min.	0.5 ms
	max.	0.7 ms
- 12 dB :	min.	0.5 ms
	max.	0.8 ms
- 18 dB :	min.	0.5 ms
	max.	3.0 ms
echoes records from 5 m below transducer up to the bottom		

Table 1. Settings for TS measurements
(Tableau 1. Réglages du sondeur lors des mesures de TS)

We are not able to present in this paper the absolute TS values, as the results of the calibration are not yet available. The results are expressed in relative back scattering cross section values.

1.3. Echo integration measurements

The echo integrator used was an AGENOR digital echo integrator. The data were regrouped in the same 6 mn ESDUs as for the TS measurements, using the (20 log R) TVG setting of the 102 BioSonics sounder. Agenor allows the use of 10 layers, which were adjusted by 5 meters intervals, from the surface to the bottom, the 9th layer being adjusted from 40 to 50 m and the 10th from 50 up to the bottom. A 50 mv threshold was selected, with a 0 dB gain.

2. RESULTS

2.1. Description of the echograms

The first part of the survey was performed on low density concentrations, and were not included in the data processing. We used the second part of the survey, from 9:30 pm.

During this survey the fish did not present the usual spatial distribution, and some big schools were recorded (fig. 3). This unusual behaviour is probably due to the moonlight conditions. Anyway, we were obliged to remove 9 ESDUs from the data set (4 in light-on situation, 5 in light-off).

Once this "cleaning" of the data performed, the 28 remaining ESDUs show a rather homogeneous situation, the biomass being represented by scattered fish all over the water column (fig. 4). Contrarily to the situation observed in 1987, no obvious vertical movement is visible on the echogram. It is also interesting to notice that in the deepest layers the single target show a "climbing" tendency, which could indicate either an upward migrating behaviour or a slight inclination of the transducer.

2.2 Echo integration results

a). Horizontal analysis.

The succession of the global fish density for each ESDU is presented in fig. 5, the data of light-on and light-off sequencies being separated. Except in two couples of data, the light-off values are higher than the light-on, the mean difference being 50 % . Nevertheless, when we apply statistical significance tests on this set of data, we may see that the difference between light-on and light-off data is not considered as significant at the 95 % level. Considering the high degree of variability of the set of data, and the fact that we do not use real couples of values, we must be very careful when extracting conclusions from these kind of observations.

b). Vertical analysis

The difference on the 28 unpaired values of density in the upper layer (13 light-off, 15 light-on) is very important (54 %) but not significantly different from zero (for $P = 0.05$) owing to the large variability of the data. A log-transformation was used to obtain the homogeneity of the variances. A t test on 21 paired values of contiguous ESDUs allowed for a decrease in the variability of the difference between means, and therefore indicated that this difference is significantly different from zero (for $p = 0.01$).

Comparing the mean values of integration for each layer, we may observe that this clear difference between the light-on and light-off data of the shallow layers (depth less that 20 m) does not appear in the deep layers (more than 20 m): the biomass difference already noted appears exclusively in the upper layers: it seems that the light has no effect at depths lower than 20 m. The figure 6 shows clearly that in this case there is no vertical diving avoidance.

2.3. Back scattering cross section results

a) target counting

When considering all the data from 9:19 pm to 11:45 pm (fig. 7), we obtain more or less the same kind of results as in fig. 5 : the number of individual targets as counted by the dual-beam system is generally lower in the light-on periods than during the light-off. This could be due either to a escapement of the fish or to a compacting behaviour which would reduce the number of avaliable individual targets for the dual-beam echo-sounder. When comparing the echograms, we may suppose that lateral escapement is the main responsible factor.

Then we counted the targets within the superior and the inferior level (fig. 8): the results are parallel to those of echo integration: the number of target decreases in the upper layer (5 to 17 m) while it remains approximately constant in the lower strata (17 to 30 m).

b. TS variations

When considering the average back scattering cross sections (fig 9), we can see that contrarily to the average densities, the individual echoes remain much more constant. There is still a lower level of the values when the light is on, but not so evident and important as on the density measurement.

If we observe the data separately by 2 meter layers, we may see one more time the same difference between the upper and lower layers (fig. 10): all the difference between the data of the ESDUs is due to differences in the upper layer.

It is not yet possible to discriminate between the two hypothesis above mentioned, i.e. lateral escapement or tilt angle variation, which one is responsible of the variations in the density. In order to make such a discrimination, we draw the frequency histograms of the backscattering cross sections in the shallow and deep layers (fig 11): we can see that the modal values are identical in all the cases, and that the decrease of the mean in the shallow layers is due to the absence of the biggest targets (which are suspected to represent a different species, probably predators, as Carangids, barracudas, etc..).

DISCUSSION

The first observation we can extract from this work is that the behaviour of the fish is depending on many factors: the species concerned, environmental variables, artificial stimuli, and may be different from a survey to the other in certain cases. The usual diving behaviour we have observed several time in this area (and included a few days after this experiment) was not present during this small survey. This could probably be linked to the unusual concentration of big night schools.

Therefore the decrease of the global densities could be due to either lateral escapement or changes in the tilt angle of the fish. If we consider that on the one hand the number of present targets decreased in the same way as the global density, and on the other hand that the observed decrease of the mean back scattering cross section was mainly due to the lack of the biggest targets, we can conclude that the decrease of the biomass in this experiment is explained by lateral escapement, the big fish escaping more than the small ones.

Finally a third conclusion on these data, when comparing to the other identical experiments we have performed in this area (vertical avoidance), is that, as there was no difference in the mean back scattering cross section of the fish whether the light were switched on or off (once removed the values of the big targets), the fish were most probably always in an horizontal position when overpassed by a survey vessel: the behavioural scheme would be the following:

- the fish perceives the noise of the boat at a long distance and moves to an horizontal "warning" position.

- when the light is perceived, and according to other behavioural parameters (moon light ?), it choses a spatial "secure place", either by diving or through a lateral escapment. This behaviour takes place before the boat passing over the target; when it occurs, the fish is already in this "secure position", and consequently is still horizontal.

CONCLUSION

The phenomena described explain why in former surveys we have not seen biomass differences between light-on and light-off data.

Moreover, it leads to the following conclusion: the TS values obtained with a cage, and the integration constant calculated by this way must take into account the values for horizontal fish more that those for other tilt angles. In this case, we may consider that it is prefereable to use the results of cage experiments performed by day than by night. The visual control (video camera) of the position of the fish being evidently indispensable.

It allows us also to compare directly the "in situ" TS values obtained by day and by night, without having to apply on them any tilt angle correction (at least for the upper layers).

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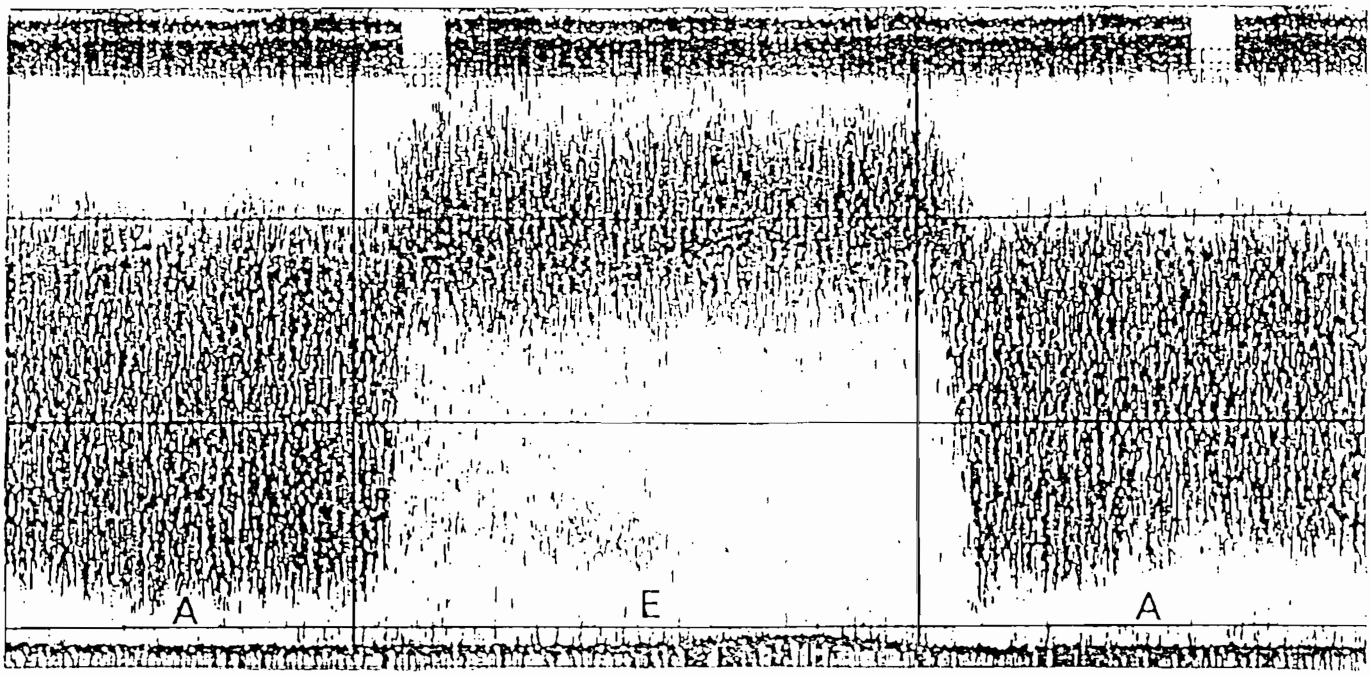


Fig. 1. Example of avoidance reactions of the fish to the light
A = light on E = light off
(from LEVENEZ et al., 1987)

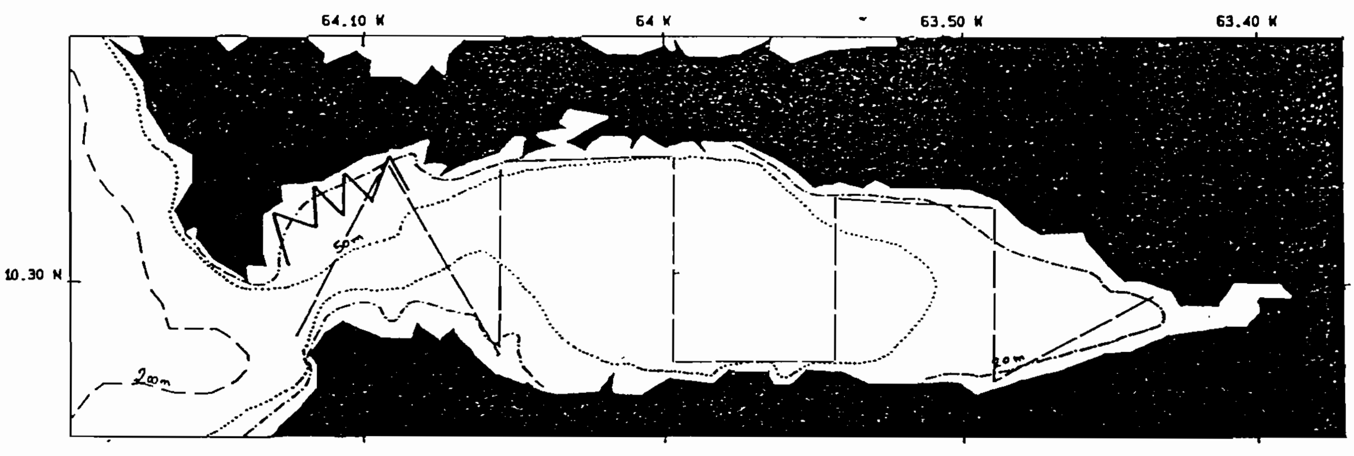


Fig. 2. Prospection and experiment transects in the Gulf of Cariaco (Eastern Venezuela)
- - - prospection ——— experiment

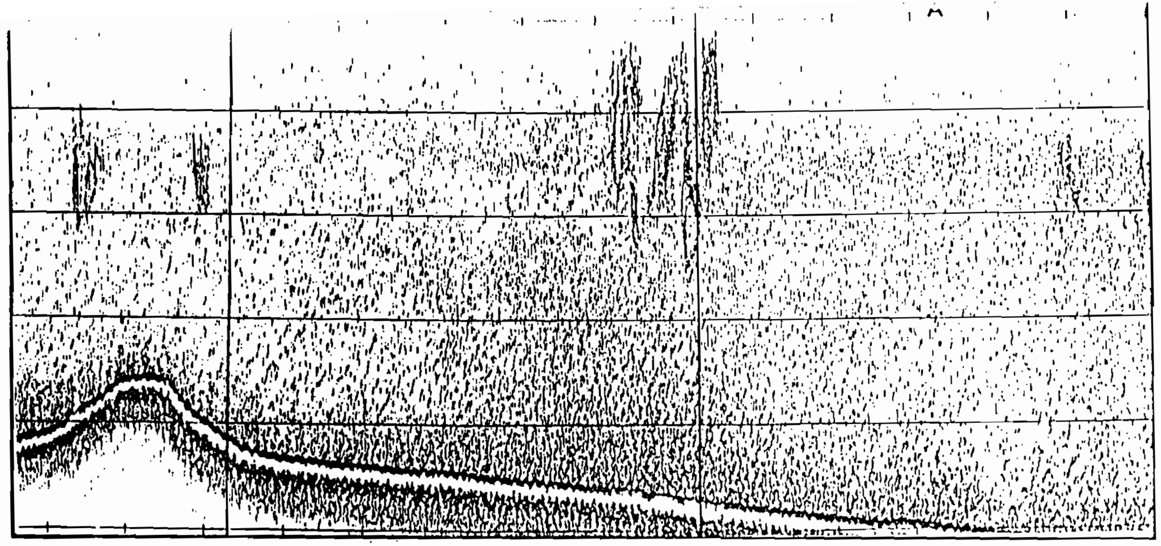


Fig. 3. Echogram of some schools observed by night in the area of experiment (paper scale 0/50 m)

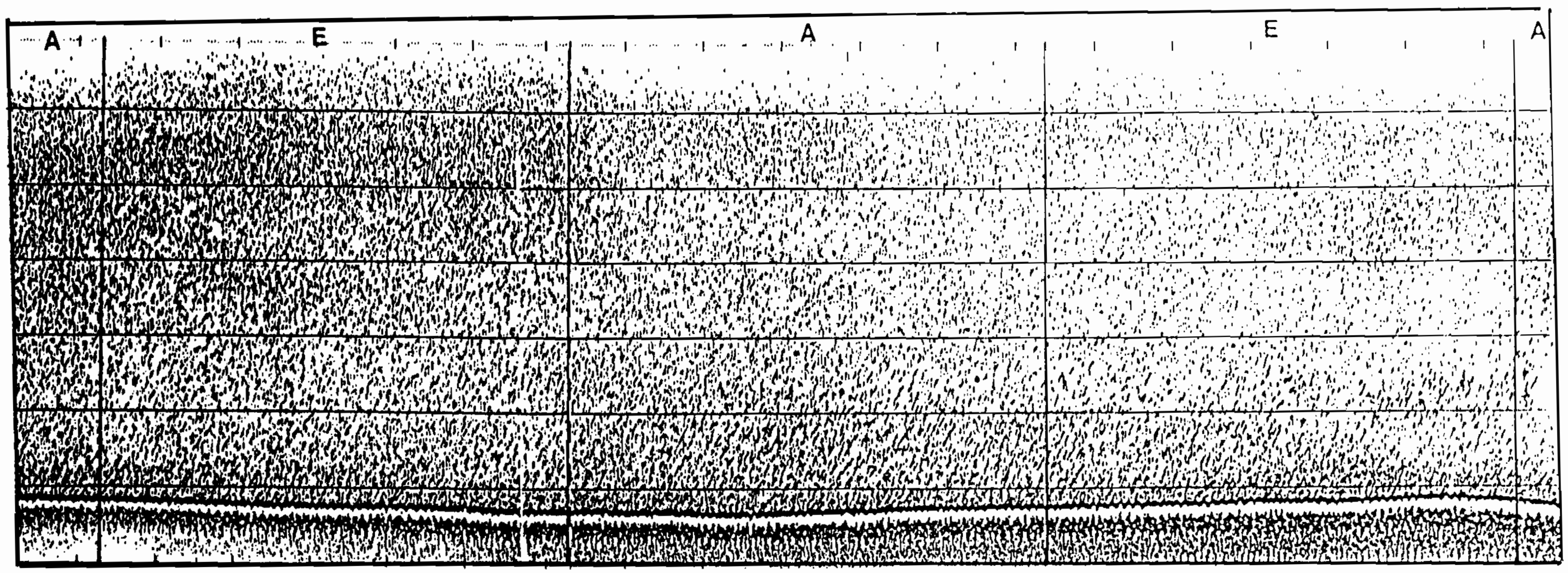
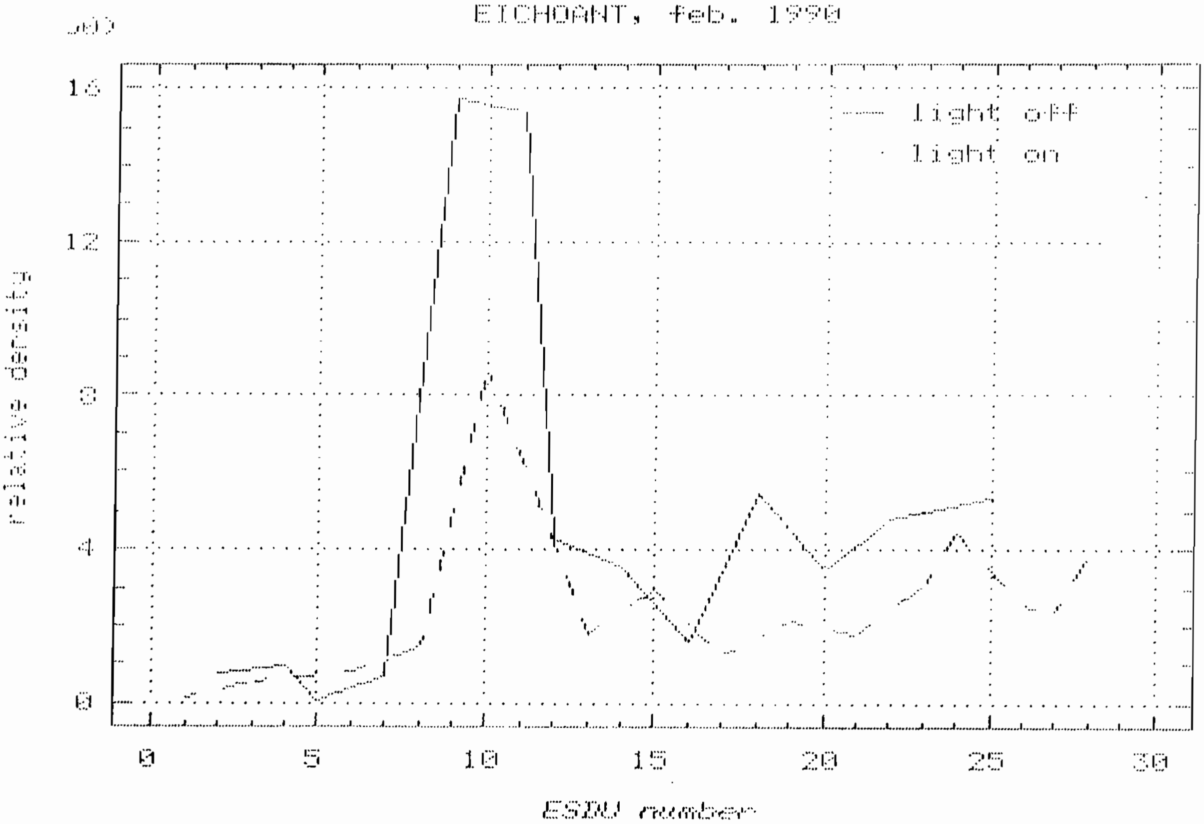


Fig. 4. Example of some light-on/light off ESDUs
A = light on E = light off (scale 0/70 m)

Fig. 5. Evolution of the total density
EIChOANT, feb. 1990



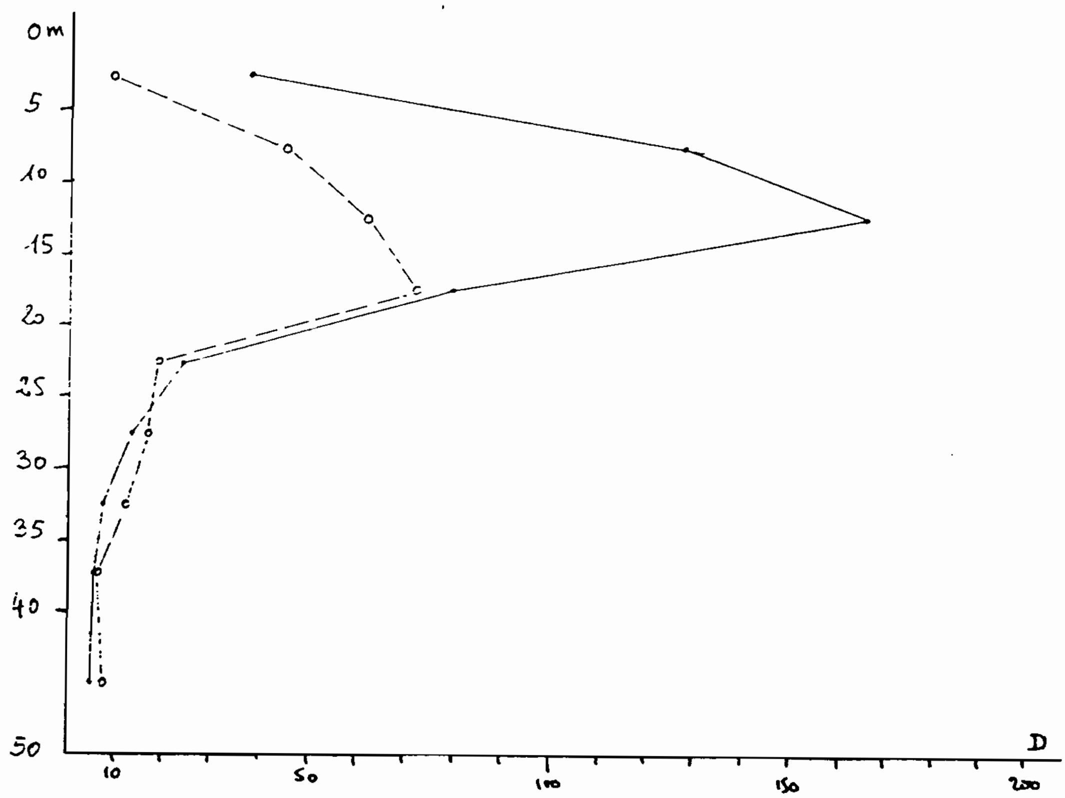


Fig. 6. Mean variation of the density by 5 meter layers in relative units.
o- - -o light on ●——● light off

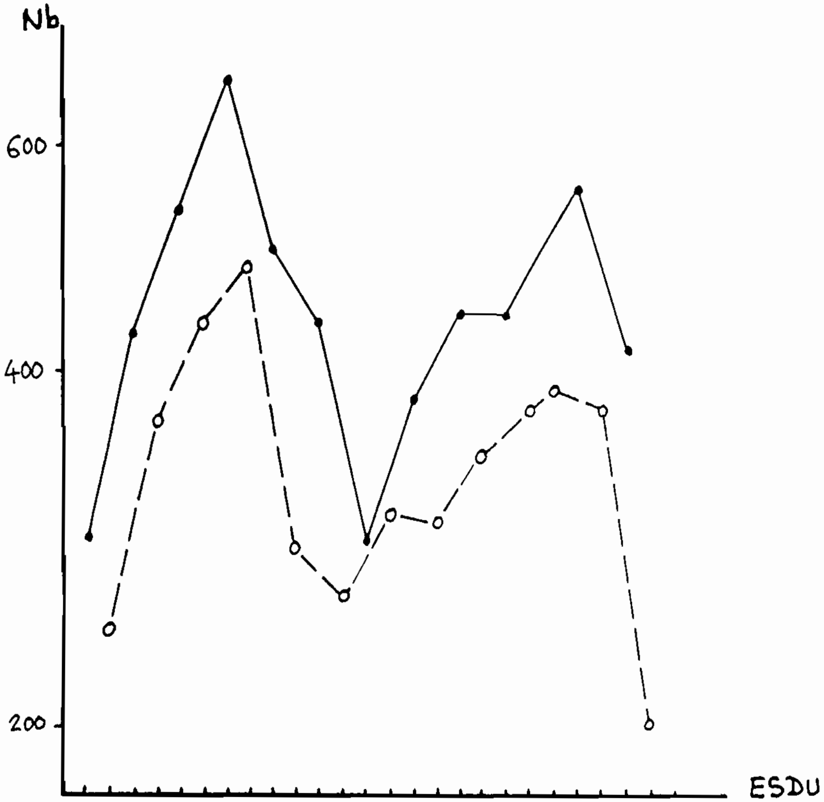


Fig. 7. Number of individual target observed through dual-beam results for each ESDU
o- - -o light on •——• light off

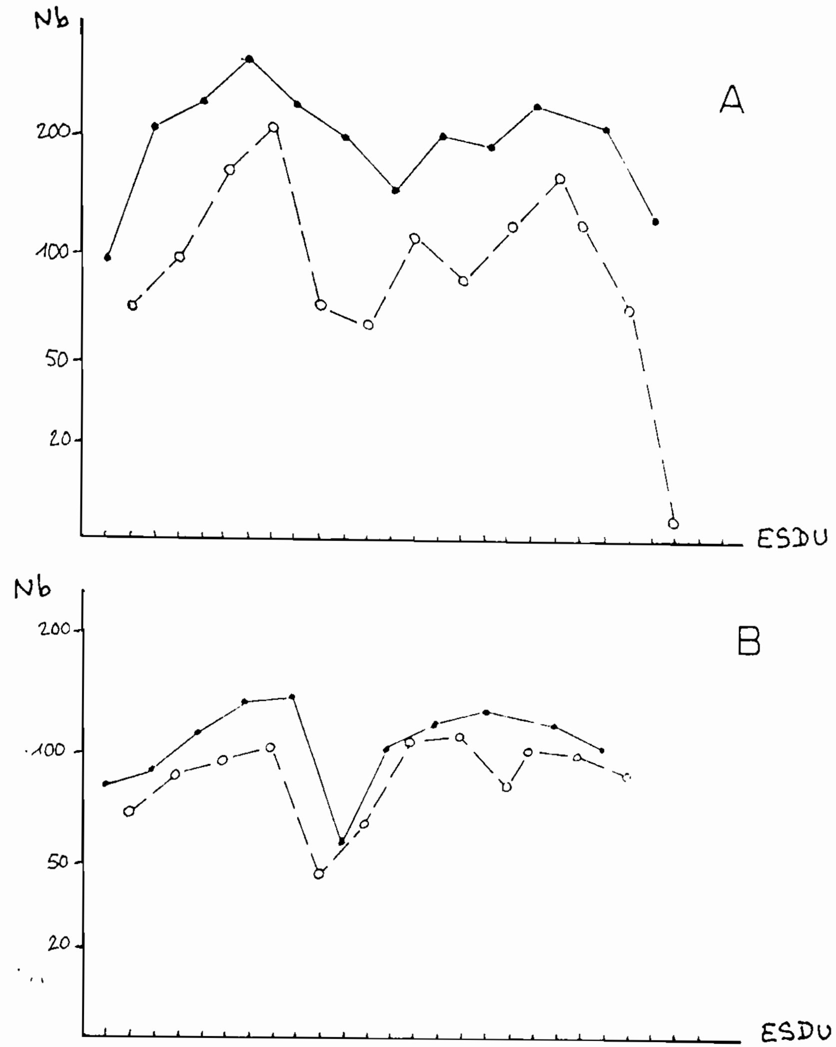


Fig. 8. Number of individual targets observed through dual-beam results for each ESDU and:
A = for the upper layer (5/17 m)
B = for the lower layer (17/30 m)
o o light on •——• light off

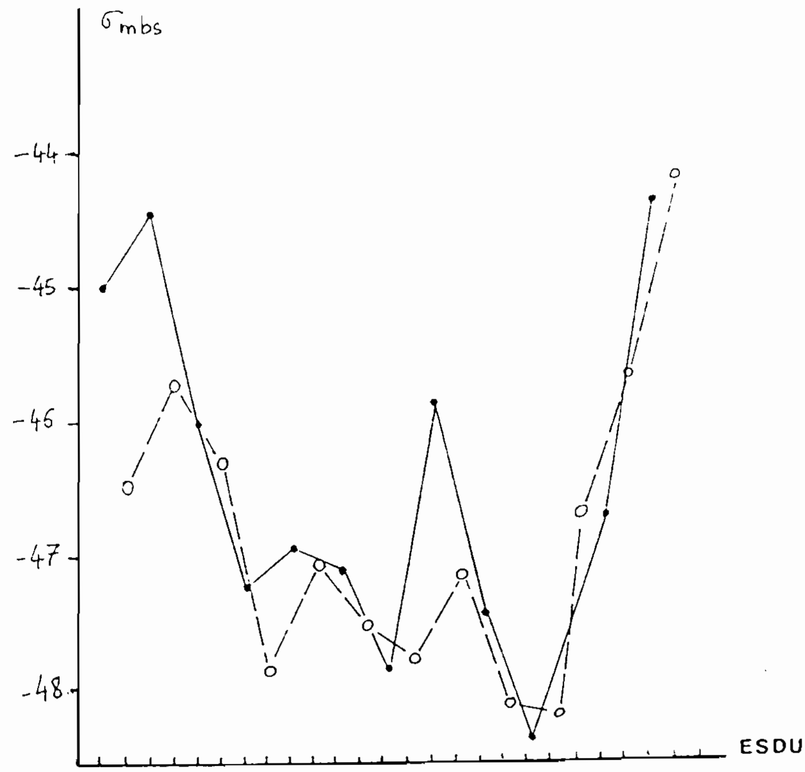


Fig. 9. Variation of the mean back scattering cross section for each ESDU
o- - -o light on ●——● light off

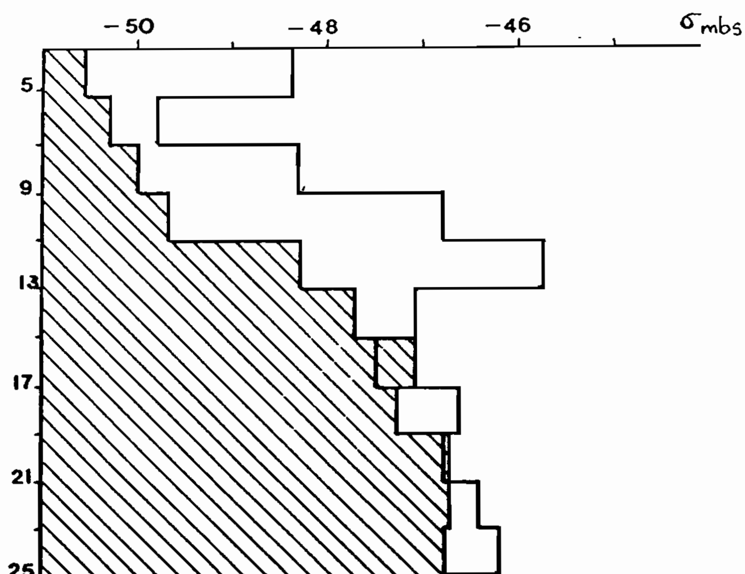


Fig. 10. Mean value of the mean back scattering cross section by 2 meter layers (all ESDUs included)
light on light off

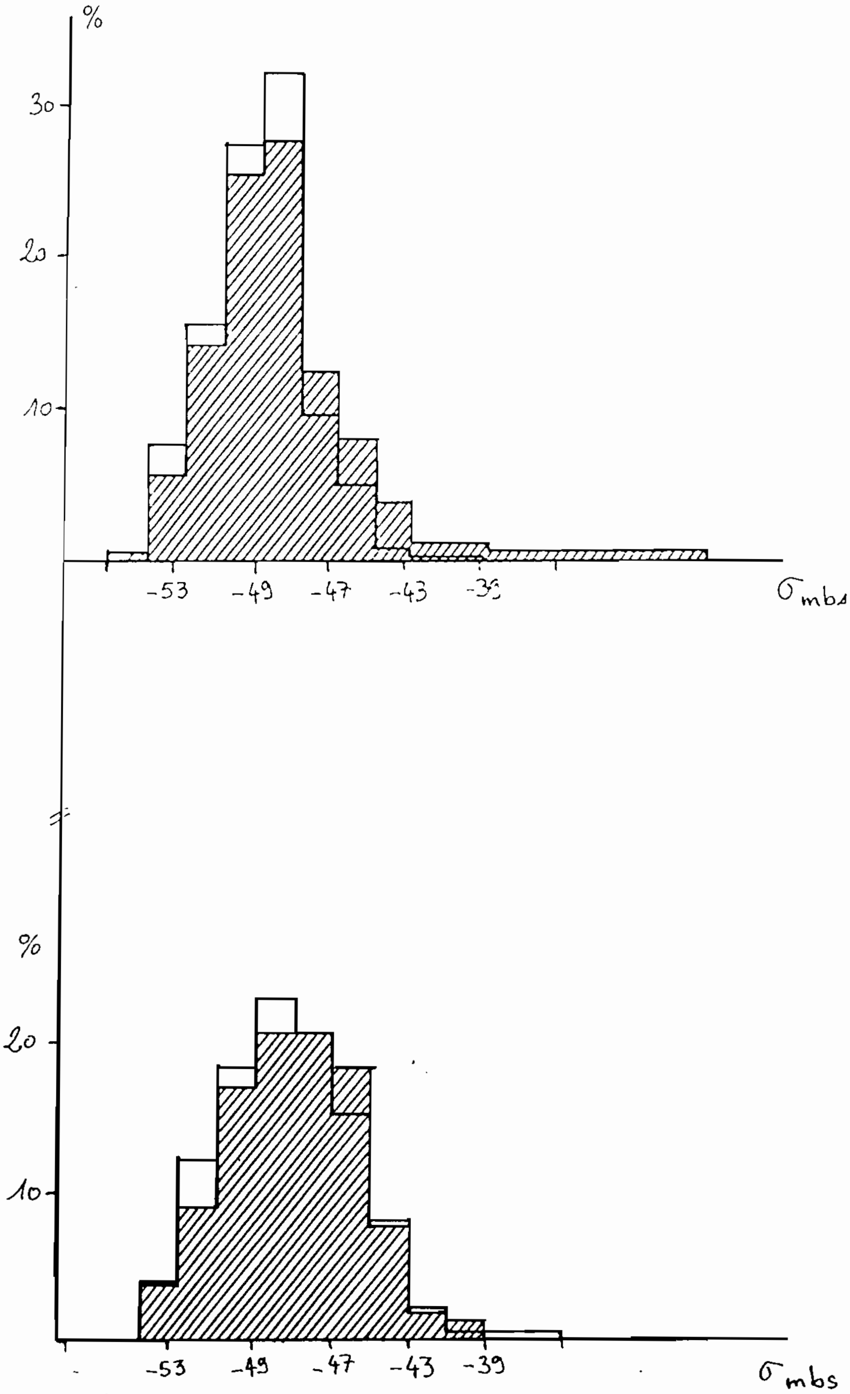


Fig. 11. Frequency histogram of the back scattering cross sections of all the targets observed
A = upper layer (5/17 m)
B = lower layer (17/30 m)
light on light off