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REACTION OF TROPICAL COASTAL PELAGIC SPECIES TO THE ARTIFICIAL LIGHTING AND IMPACTS ON THE ESTIMATIONS OF ABUNDANCE BY ECHO-INTEGRATION

BY

Jean-Jacques LEVENEZ (1), François GERLOTTO (2)

and

Didier PETIT (3)

(1) ORSTOM, CRODT-ISRA, B.P. 2241, Dakar Sénégal.
(2) ORSTOM, Centre ORSTOM de Fort de France, B.P. 81, 97201 - Fort de France.
(3) ORSTOM, IFREMER, B.P. 337, 29273 Brest Cedex

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A B S T R A C T

The study of the fish behaviour in a tropical environment and its consequence on the estimates of the biomass from echointegration techniques have been conducted on both sides of the Atlantic, in Senegal and Venezuela. Three series of experiments realized nightly at 15 to 3à meters depth have shown that when the lights are lit up on the running research vessel, the fishes dive or/and spread but the consequences, as far as echointegration is concerned, depend on the species of fish and on th speed and the direction of the lighting on the boat : when the lights are focused only laterally (Senegal) the biomass estimates can decrease by a dramatic factor while, if the lights enlight forewards (Venezuela) the fishes are deeper but more or less stabilized before being insonified, hence without direct consequences ont the biomass evaluation.

R E S U M E

Des études sur le comportement du poisson en milieu tropical et ses conséquences sur les estimations de biomasse par echo-intégration ont été menées de chaque côté de l'Atlantique, au Sénégal et au Vénézuela. Trois séries d'observations réalisées de nuit à des profondeurs comprises entre 15 et 30 mètres ont montré que lorsque les lumières de pont sont allumées sur les bateaux de recherches, les poissons plongent et/ou s'écartent, mais que les conséquences, en ce qui concerne les évaluations de biomasse, dépendent des espèces, de l'orientation de l'éclairage du bateau et de la vitesse de ce dernier. Quand les lampes éclairent latéralement (Sénégal) les évaluations de biomasse peuvent être grandement sous-estimées, tandis que si les lumières sont focalisées vers l'avant (Vénézuela) les poissons plongent mais sont relativement stabilisés avant d'être insonifiés, et par conséquent cet effet ne biaise pas les estimations d'abondance.

I N T R O D U C T I O N

The effects of artificial light upon fish concentrations have been studied from the beginning of the hydroacoustics research. HODGSON and RICHARDSON (1949) and RICHARDSON (1952) have shown that the depth of a fish concentration could be modified using the illumination of a lamp. VERHEIJEN (1959) has published results of this impact of artificial lights on the behaviour of sardines, from which it is evident that this species dives when the lamps are switched on. The same type of

behaviour has later been observed on other species in a temperate environment. The tropical environment has been less studied ; however, we can find, in OVTHINNIKOV et VOSMITTIEL (1971), the results of visual observations made from a drifting research vessel along the west african continental shelf and around the Canary Islands ; they note in particular, for Sardinella maderensis that "after having switched on the white lights, a big quantity of fish has disappeared", and for Sardinella aurita that, "after suddtently having switched on the submarine lamps, the fish went deeper and a significant time lapse (20 à 25 min.) was needed before they returned fo the illuminated area.It is moreover known, and this has in particular been discussed by OLSEN (1971 an 1979), that certain species have a strong tendency to withdraw when a boat approaches and this is due to the low frequency noise generated mainly by the propellers.

In the tropical environment where the echo-integration is increasingly developing, it was, first in a very global way, necessary to measure the impact of these different behaviours, results of visual and auditive stimuli, on the estimations of abundance by the acoustic method. Three series of experiments have been conducted, two in Senegal and one in Venezuela, and the results are shown in this paper.

1 . MATERIEL AN METHOD

In Senegal (map 1), the observation have been carried out from the R.V. Laurent Amaro, a research vessel with a stern

trawl equiped with a Biosonic 120 kHz echosounder and integrator. Its bridge spoligths (?) are facing backwards and the towed transducer is at the adge of their direct lighting area (fig. 1).

The first series of observations was done during the nights in the Goree bay (map 1) with 15 m depths and waters with abundant juvenile sardines, which serve as bait for the tuna bait boat based in Dakar.

It needed the technical support from the R.V. Cauri which served as assistance versel ; this latter was anchored and held, at about 30 m distance, a raft with a week signalling light, which supported the 120 kHz transducer and a small diving lamp installed in order to fix the fish under the raft (fig. 2). The R.V. Laurent Amaro passed just beside this raft several times at different speeds and with the bridge lit up or not ; and the reactions of the fish were observed directly on the echograph and recorded on cassette for later processing in the laboratory.

The second series of observations took place in the northern Casamance area (map 1) at depths of 25 m. While the vessel advanced at its usual cruising speed, that is 8 knots, the lights on the bridge were on and off alternatively with a 1 minute periodicity, this time lapse corresponding to a distance of 247 m. The reactions of the fish were observed on the echograms.

In Venezuela, the experiments were carried out from R.V. Capricorne, at approximately 25 m depth, where a control catch identified anchovies and 15 to 20 % Sardinella aurita. The

vessel, which was equipped with a SIMRAD sounder and an AGENOR integrator used a speed of 4 and then 7,5 knots.Its bridge projector (500 w), situated in the front, was alternatively switched on for 6 minutes and them switched off for 6 minutes, this time lapse corresponding in this case to a distance of 1389 m. This illumination was not particularly focused towards the sea. The other lights on the R.V. Capricorne were turned off or carefully covered except for the navigation lights. The behaviour of the fish was observed on the echograms and the echoes integrated during each of these 6 minutes sequences.

2 . RESULTS

2.1. IN SENEGAL

2.1.1. First experiment

Approximately 30 minutes after the installation of the experimental device, the recorded echoes on the sounder abord the R.V. Cauri showed a stable situation, where the concentration of small sized fish was very dense and homogeneous between the beginning depth of observation and 1 to 2 m above the bottom. The fish were clearly more dispersed near the bottom. (Fig. 3A).

When the research vessel passed without lights just beside the raft, no apparent reaction of the fish was noted independant of the speed of the boat (fig. 3B and 3C). The noise did in this particular case not have any determinating consequences on the

behaviour of the fish.

On the contrary, when the vessel had the lights on the bridge switched on, it was noted that :

- when it passed at a speed of 8 knots, and as soon as the area of direct illumination of the lights of the bridge reached the observation raft, an immediate decrease of the apparent densities, characterized by an absence of echoes at approximately half the observation depth and a strong decrease of the densities of the other half, was observed.

- When it passed at low speed (0.5 to 1 knot), the observations show the same immediate dispersion of the fish near the surface, rapidly followed by an apparent upwards movement of the fish near the bottom. The situation takes much longer to become stable as though a part of the fish had followed the area illuminated by the boat (fig. 3E).

2.2.2. Second experiment

This experiment, carried out in the operational conditions of the acoustic surveys, confirms (fig. 4) that the fish have an immediate reaction to the luminous stimuli, and a sudden illumination causes them to dive according to our observations 10 to 12 m, which leads to a general concentration of the fish close to the bottom.

It also shows that, on this type of fish concentrations, the reactions are reproductible with, the fish diving to the same

depth at the arrival of the illuminated vessel as can be noted from the sequences 14 and 15 of figure 4, or staying at the same level when the bridge of the boat is not illuminated (for example : sequences 16 and 17 of fig. 4).

2.2. VENEZUELA

The reaction pattern of the fish is the same in Venezuela as in Senegal (fig. 5), that is, they dive when the vessel switches on the lights, but contrary to the situation in Senegal, where the reaction is immediate and total, a transition phase with a duration of 30 to 40 seconds was observed in Venezuela. This transition phase is shorter when the speed of the vessel is high (fig. 6 : 1 and 2).

On the other hand it can be noted that the fish nearest the surface dive 5 to 8 m and the part of the fish situated further down dive 12 to 18 m.The amplitude of this migration also depends on the speed of the boat (fig. 6 : 1 an 2) ; and there is consequently an apparent increase in the extension of the concentration which is correclated to a decrease in its density.

If can als o de noted, referring to figure 5, that the fish do not dive all the way to the bottom, contrary to what was observed about the R.V. Laurent Amaro (fig. 4).

The integrations of these fish concentrations have as results the following global relative values :

- mean of 40 "illuminated" sequences = 1995
- " " 40 "non-illuminated" " = 2057.

There is flues in this case no significant influence by the lithting on the two estimations of the density.

On the contrary, a clear alternate change of the values between the integrated layers during 2 successive sequences was noted, with a maximum amplitude of 20 m (Fig. 7).

D I S C U S S I O N

The small variation of the intensity of echoes recorded during a passage of the R.V. Laurent Amaro without lights near the raft seems to indicate that the species of fish observed, especially small sardines, have only a week reaction to the noise of the boat; but the presence of a submarine lamp installed under the raft to locate the fish could have disturbed their behaviour.

Thus it is difficult to make a definite conclusion on this point.

A big difference between observations done in Senegal and Venezuela concerns the reaction of fish to light. On the first case the reaction is violent when the lighting is lateral while in the second case one notices a response time of 30-40 seconds with lighting directed fowards an orientation which lets one suppose that the fish has already gone down and is stabilised at the moment insonified ; however, this is not the case. A greater turbidity of the water in Venezuela and/or a weaher power of the lights of the R.V. Capricorne could explain the apparent showness

of the reaction,but it probably is due to a slow swimming speed of the fish.

One sees that the superficial part of the layer goes down from 5 meters when the boat sails at 7.5 knots, but is sinks at 8 meters when the boat sails at 4 knots. On the other hand, the lower limit of the layer of fish sinks 14.5 meters in the first case and only 10.5 meters in the second.

Many hypothses can be famulated regarding the specific differential sensitivity to boat noise and te sound and light stimuli combined, but lack of precise information doesn't support them. Thus, it is difficult to known even though global estimations of density are identical for illumination and extinguishing if the fish have had enough time to stabilize their depth upon the arrival of the boat.

This would intense the accuracy of these estimations. The geatest density of concentration when the light is turned on only characteries multispecific detections (at least anchovy and Sardinella aurita according to results of fishery operations) hairly swimming speeds and reactions to different stimuli. The fact that they don't go down to the bottom could be in past linked to the boat's of the leater and the power of the lighting which permits the fish to escape from the bright stimulus before they teach the level of the bottom.

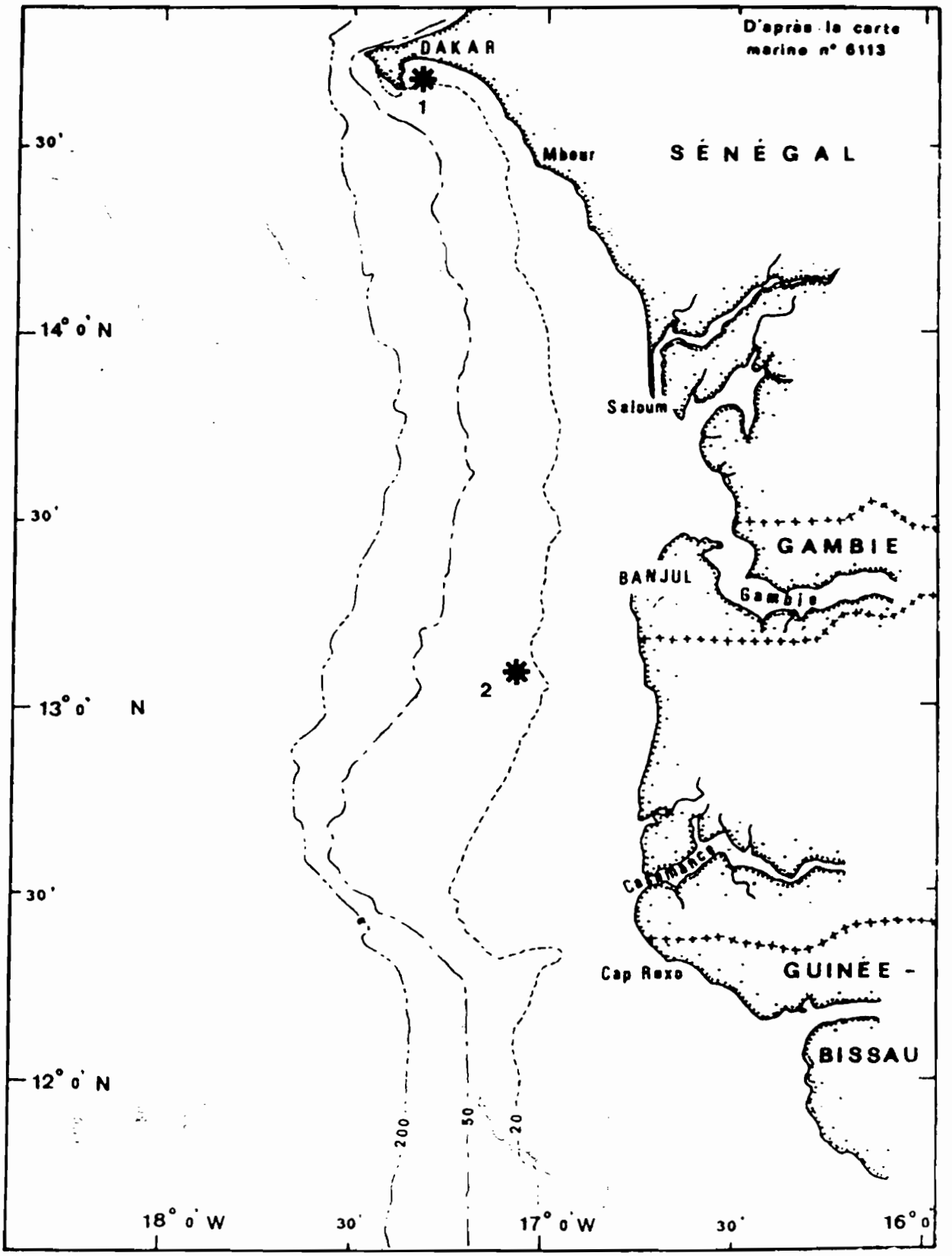
On the other hand, in conditions observed in Senegal the light makes these fish bunch up toward the bottom,consequently the density of the concentrations diminished from 10-12

meters;the decrease not necessarily correctated to an augmentation of density. In this way one can see it on the echograms, which means that the fish escaped laberally in relation to the ship and/or that it has an orientation in relation to the horizontal which expresses weaker index of reflextion. Moreover, the fractions of fish which doing to the bottom escape the integration zone which leads to a large underestimation of densities.

C O N C L U S I O N

On the three series of experiments presentes here, the influence of artificial light on tropical fish behaviour is considerable.

If in the example of prolonged stationary illumination, fish are generally attracted, a violent illumination makes them move away from the light source at first. The second case, which conserns more exactly echo-prospection compaigns, should be seriously taken into consederatin for it is the case for experiments done in Senegal. It can lead to a serious underestimation of biomasses. Quantative studies in this area are thus recommended to reduce as much as possible sources of bias in the evaluation of biomass in stocks of tropical coastal fish. In the absence os such studies it is undoubledly preferable to do night compaigns in tropical areas with a minimum of light on research vessels.



Carte 1 :-

Geographical area of the observations in Sénégal

1°) Bay of Goree

2°) Northwest Casamance

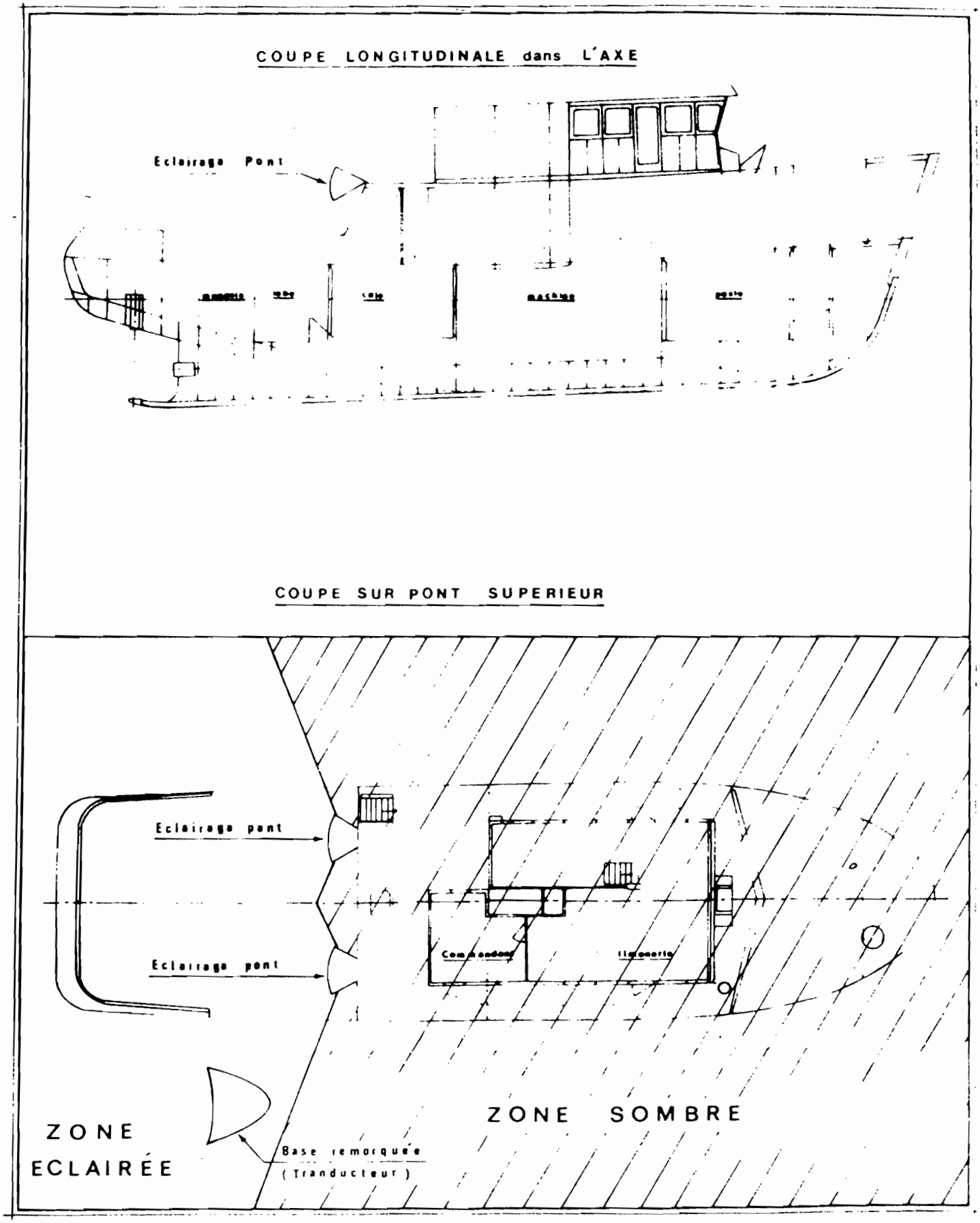


Figure 1.- : R.V. Laurent Amaro
Position of the lightspots

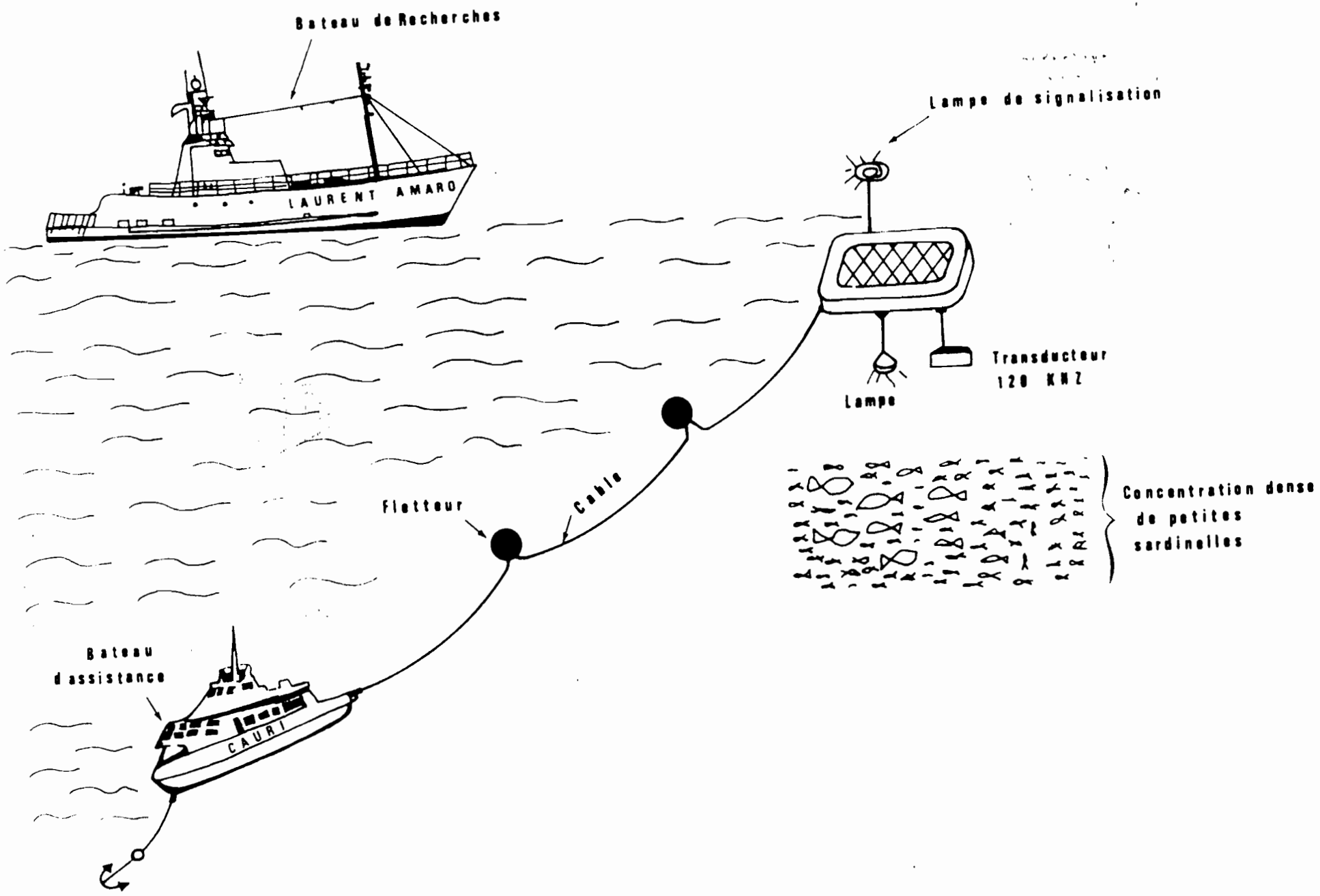


Figure 2.- : Experimental set up for fish behaviour observation

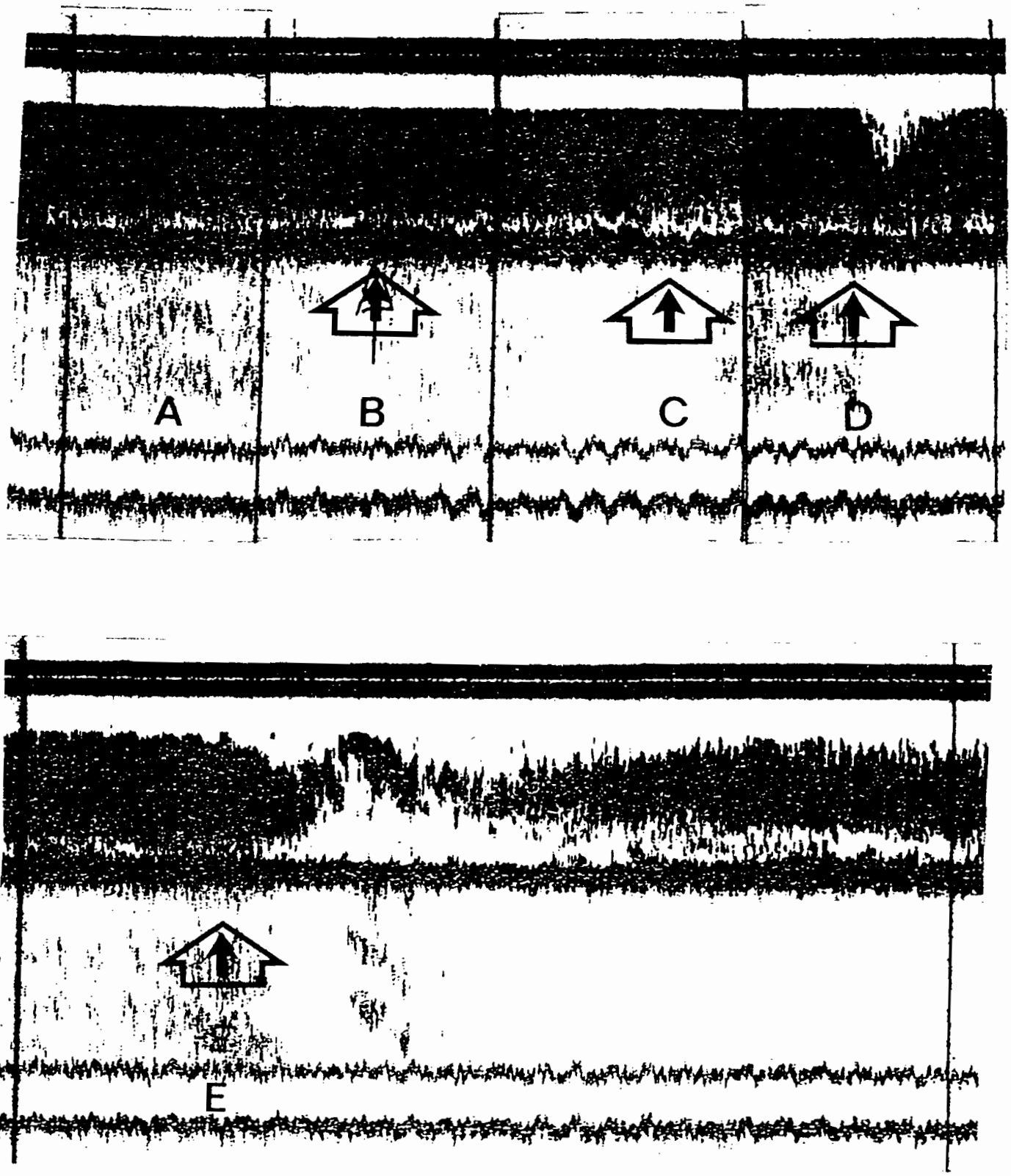


Figure 3.- : Echogrammes showing the fish behaviour to the lighting (See explanations in the text).

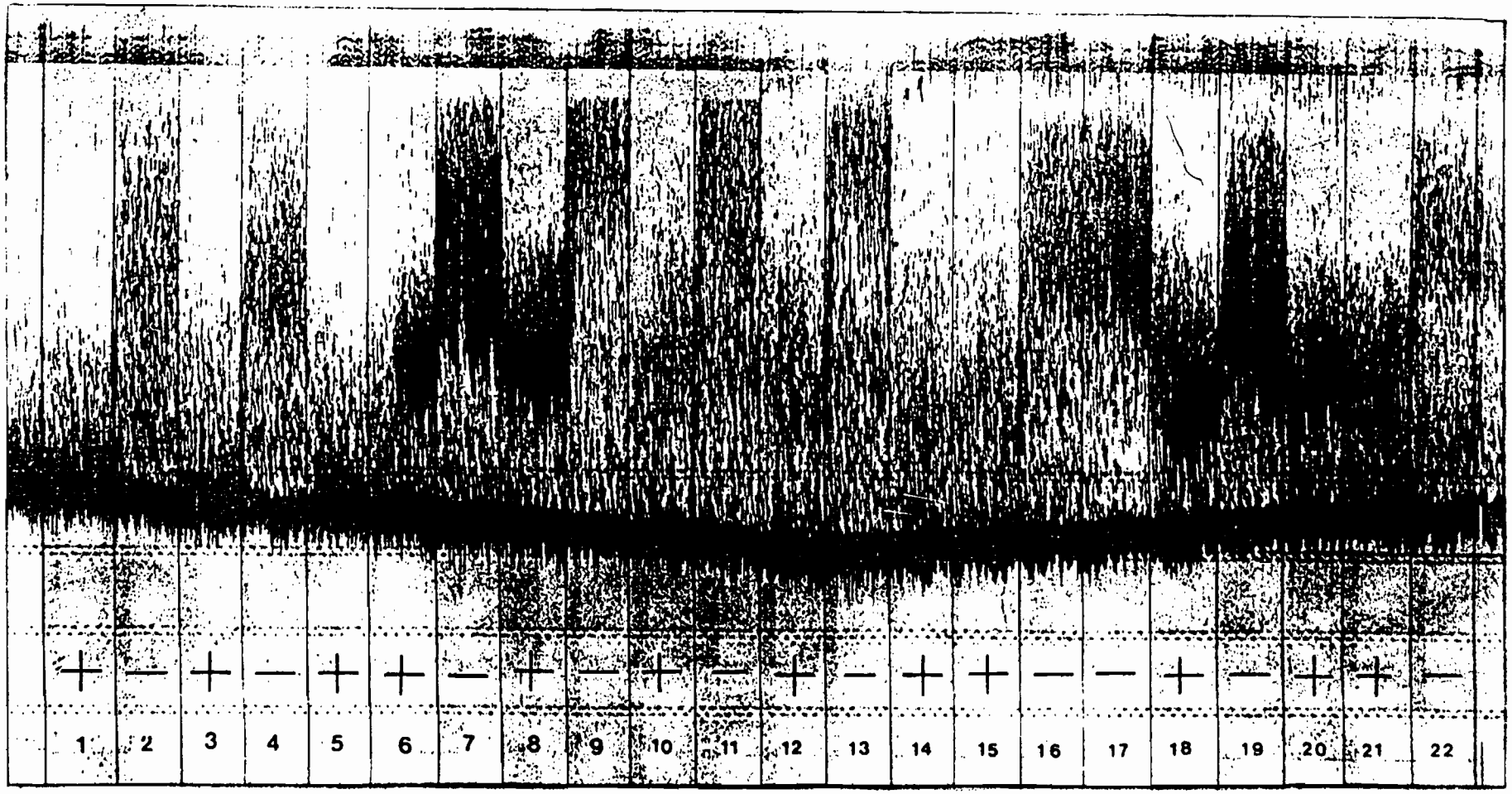


Figure 4.- : Fish reaction to the light :
Northwest Casamance arrea 25 m. depth.
+ = With light
− = Without light

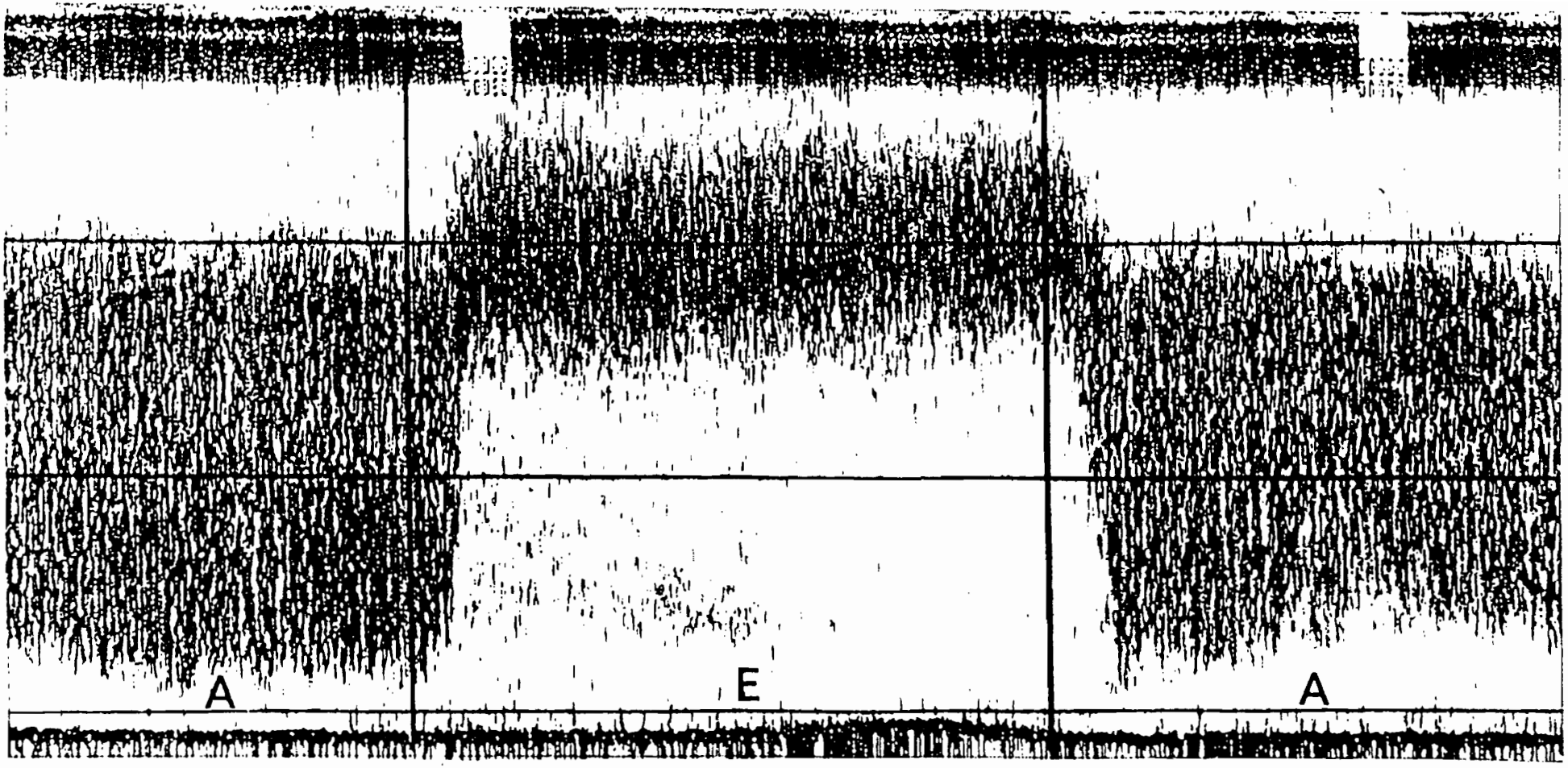


Figure 5.- : Fish reaction to the light in Venezuela
R.V. Capricorne speed : 7.5 Knots
A = With light
E = Without light.

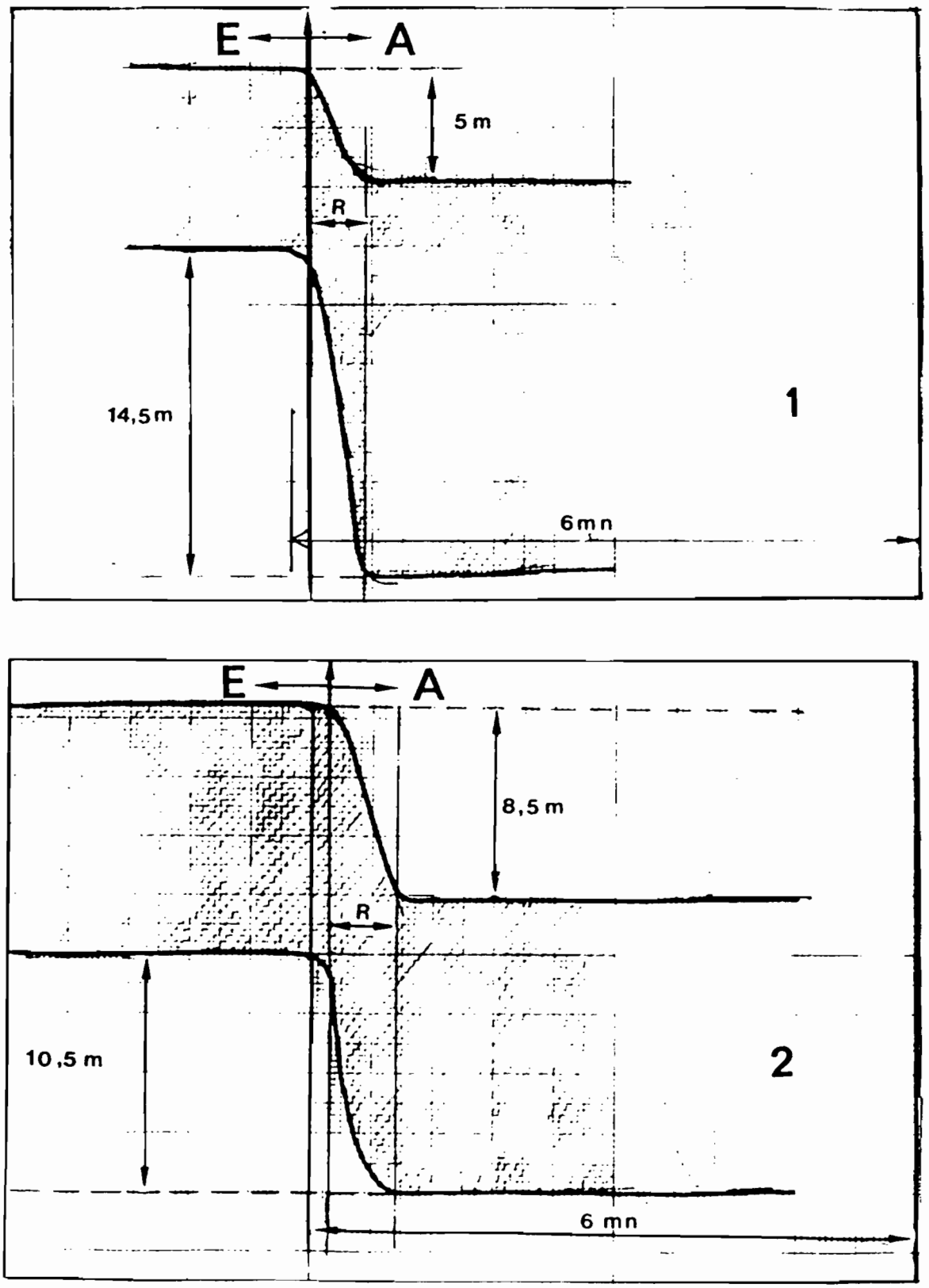


Figure 6.- : Changes in a scatlered fish lager
Caracteristics during the experiments
1 Speed = 7.5 knots ; 2 Speed = 4 knots
A = Nith light
E = Without light

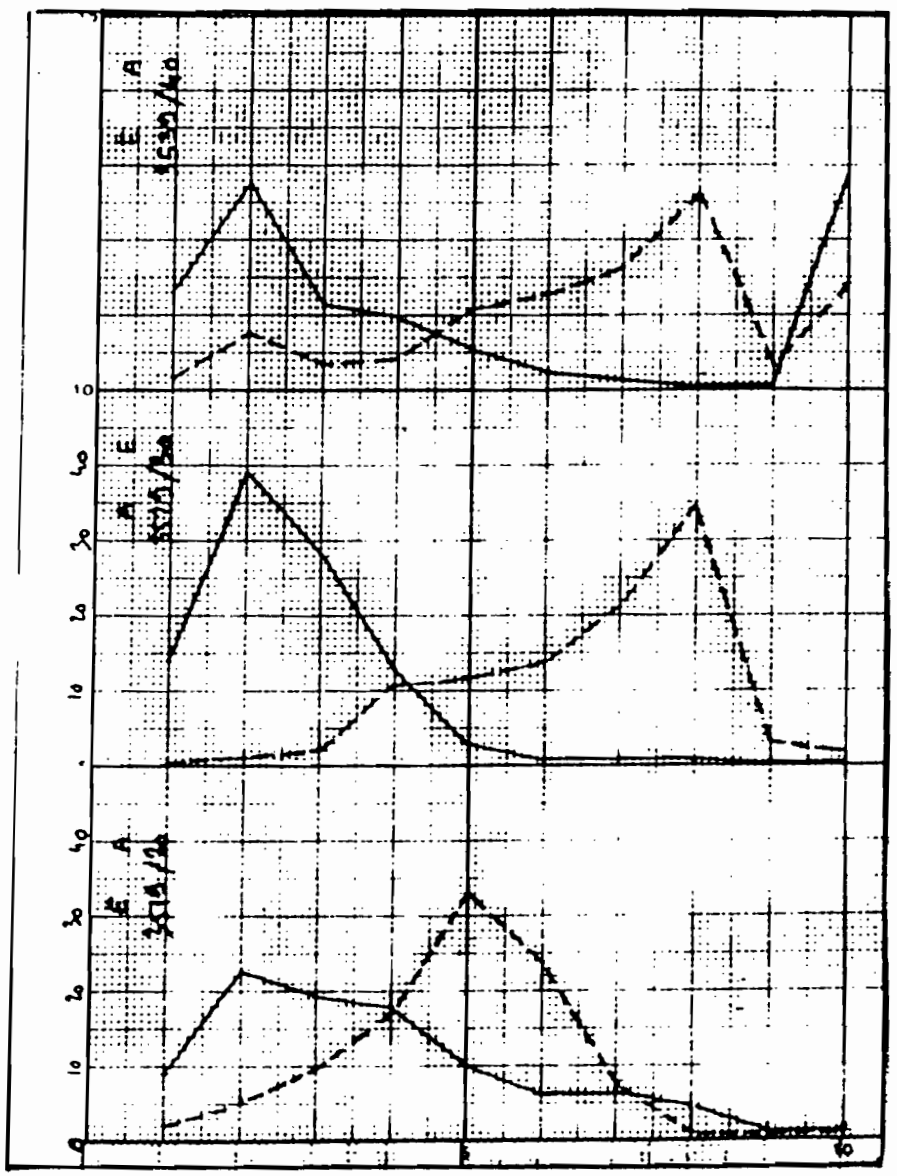


Figure 7.- : Example of density changes with depth
____ With light
.... Without light

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