ECHO-INTEGRATION SURVEY AROUND OFF-SHORE OIL-EXTRACTION PLATFORMS OFF CAMEROON: OBSERVATION OF THE REPULSIVE EFFECT ON FISH OF SOME ARTIFICIALLY EMITTED SOUNDS

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ABSTRACT

Fish concentrations below the platforms in oil-extraction fields off Cameroon are a favourable situation for studying the effect of emitted sounds on the behaviour of the fish. An experiment has been conducted around some platforms, using either natural predator noise records or pure frequency sounds. The fish concentration were mapped before and during the experiments using a Simrad EY-M echo-sounder and an AGENOR echo-integrator. Two kinds of fish are concentrated around the platforms: schools of small pelagic species and big scattered fish. The first species are distributed over the total area by day, and partially concentrated by night below the light of the flare, while the second are permanently present in rather important quantities very close to the structures. The effect of the sounds are different on the two groups: immediate strong repulsive effect on the small fish, inversely proportional to the distance from the point of sound emission; lower effect on big fish which seem to remain under the platforms.

INTRODUCTION

The behaviour of fish with respect to echo sounding may bring some biases in the results of an acoustic survey [1]. Fish reactions are generated principally by two stimuli coming from a boat: noise and light. Few authors have presented observations. Some of them [2] show results where noise appears to be the principal stimulus, allowing them to calculate and propose models to overcome its impact. Other [3], [4], found the light to be the determinant factor influencing the behaviour. A discussion on this point has been presented recently [5].

One interesting way to collect new information was to do some studies around offshore oil extraction platforms: these constructions are strongly attractive to fish, especially when they are equipped with gas flares. As the platforms support various permanently working engines, such as pumps, electric plants, etc..., and are daily visited by noisy, high-powered shuttles, it can be assumed that fish quickly become indifferent to usual mechanical noises. Thus it seemed possible to study wether a new artificial sound could stress the fish and to evaluate the influence of this sound compared to light attraction. That was one of the purposes of an acoustic survey carried out in march, 1988, on an oil-extraction field off Cameroon.

1. MATERIAL AND METHODS

1.1. Material

The survey was performed aboard the R/V "André Nizery", a 25 m scientific stern trawler. Two echo-sounders were used, a fixed 120 kHz SIMRAD EKS and a portable 70 kHz SIMRAD EY-M. Observations were carried out from the research vessel, or aboard a small inflable dinghy or a 10 m shuttle. Data were directly processed through an AGENOR echo integrator, or previously recorded on a magnetic audio tape for further processing aboard.

Two kinds of noises were produced through a system detailed elsewhere [6]: a single frequency continuous noise, the frequencies of which were chosen within the audiogram of the fish 200 to 2000 Hz), and records of predators, such as cetaceans (Orca orca).

Three trawl sampling were done in the exploitation field, using a bottom trawl.

1.2. General survey

A large area around two extraction fields were surveyed by day and by night with the R/V Nizery, using a classical grid, with parallel transects and 6 knots/3 minutes distance units. The survey was designed to include prospection as close to the platforms as possible, generally less than 50 meters (fig. 1).

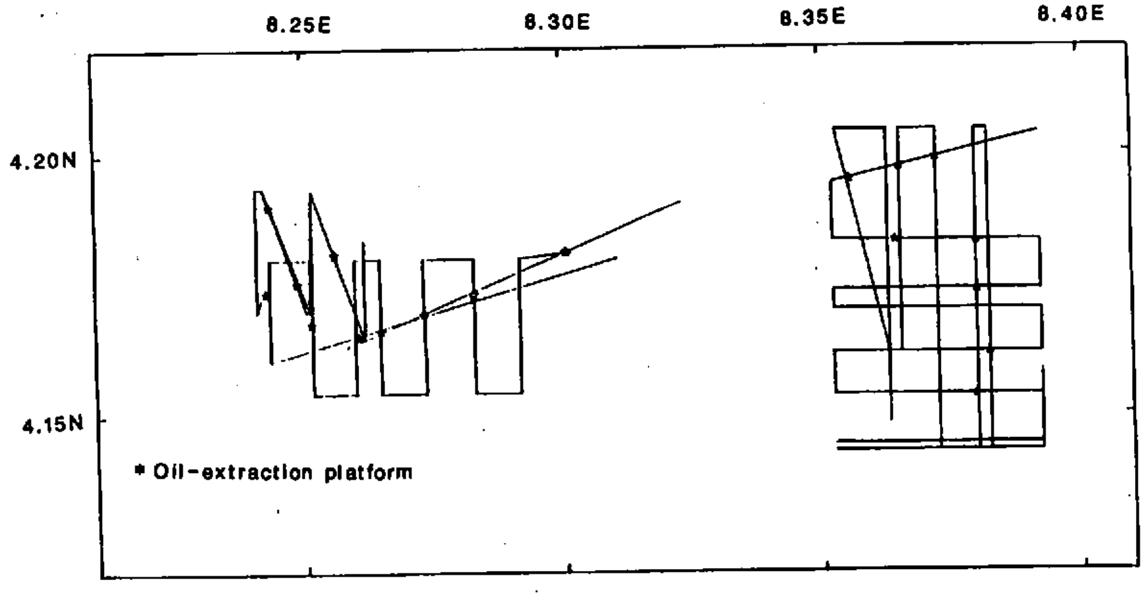


Fig. 1: General grid around oil-extraction fields

1.3. Platform surveys

In order to have data around the platforms, a special grid has been designed, and covered by small boats, using the EY-M.

-a) by day: the survey, done aboard a small inflable dinghy, consisted in 3 circles at 5, 15 and 30 meters around the platform (the 30 m radius corresponding to the length of the flare arm), and two 200 m transects, respectively S-N and W-E, crossing each other very close to the platform center.

-b) by night: the surveys were performed on a 10 m, 400 HP shuttle, at the same speed as the dinghy (about 2 knots); the survey consisted in 3 circles, at 10, 20, 50 m around the platform, and one 200 m, S-N oriented transect, centred on the light of the flare.

1.4. Sound emissions

The first step was to select a frequency for the emission which was carried out

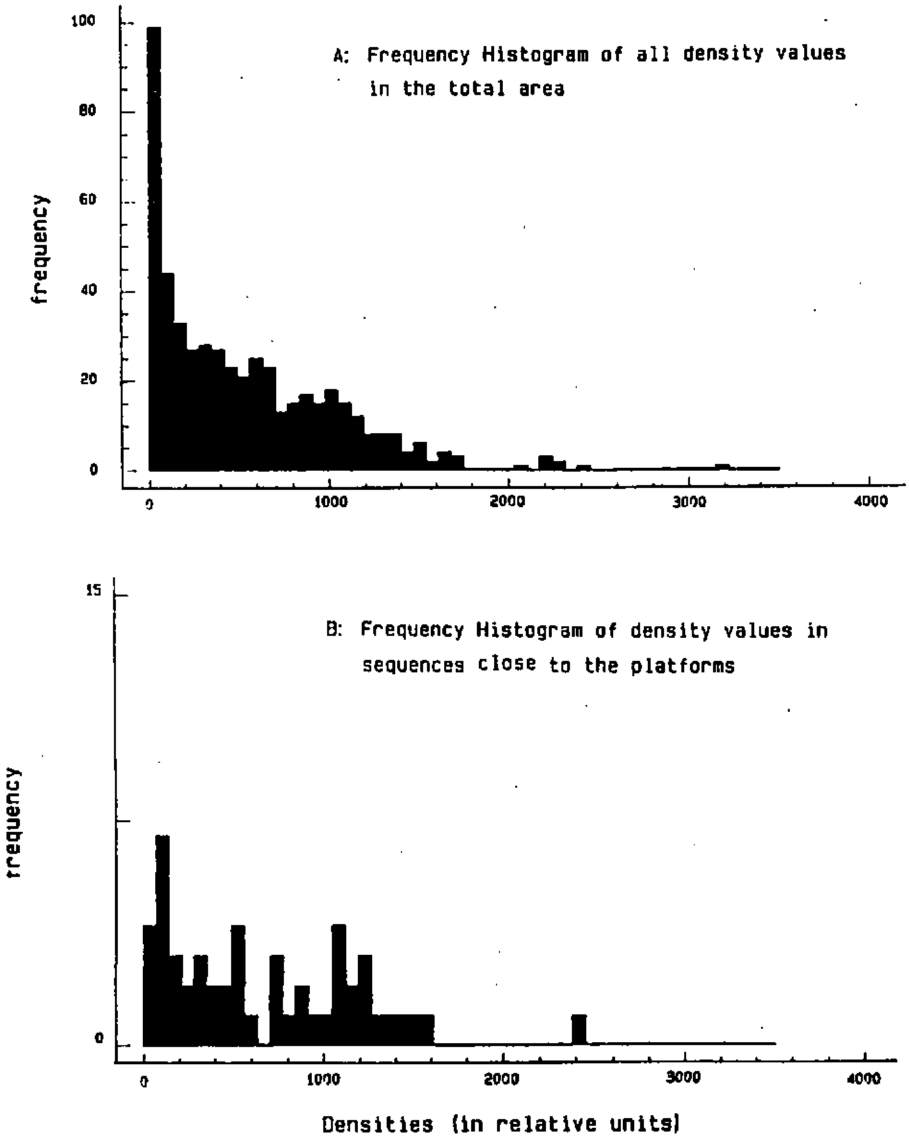


Fig. 2: Influence of platform proximity on fish density for 0.5 ESDUs

aboard the R/V Nizery, through the following experiment: various frequencies were emitted from the vessel anchored in open sea, far from any platform, on fish attracted by the boat's lights. The immediate reactions of the fish to emitted sounds at 200, 250, 500, 1000 and 2000 Hz, using 1 minute intervals, was measured aboard. In the same way, records of natural noises emitted by Orca were tested, as well as Sciaenid schools noises.

Then two operations were performed:

- using the instrumented buoy designed for this purpose [6], placed close to a platform, and mapping the densities of fish around the platform, as in the general case (3 circles and 2 transects): the noises emitted were either Orca sounds or a 250 Hz sound.

- with the same sound emissions, covering a transect aboard the R/V Nizery,centred on the platforms. Mean density values were measured in the intervals 0.5-0.3 mile, 0.3-0.2, 0.2-0.1, 0.1-50 m, on each side of the platform, and in an interval of 50 m around it.

2. RESULTS

2.1. General prospection

When considering the density distributions, one phenomena can be pointed out: the very low effect of the platform on the fish distributions, when using a 0.5 mile distance unit for echo-integration; the compared histograms of density values in the distance units (ESDU) including or not a platform do not show strong differences (fig. 2). If we observe separately the data by day and by night, although a slight increase of the platform ESDU densities by night may appear, the difference is still too low to be statistically significative.

On the contrary, when using a smaller scale of observation, the tendency of fishes to concentrate near and below the platforms can be observed. Four transects were made by day with the R/V Nizery to measure this point, with evaluations of density at 0.5, 0.3, 0.2, 0.1 mile and 50 meters from the platform.

2.2. Fishing data.

The three trawl samples show a very homogeneous population all over the area, principally composed of small Clupeids (Sardinella aurita, S. maderensis, Ilisha africana) and Carangids (Vomer setapinnis, Chloroscombrus chrysurus, etc..). The only other important families are the Sciaenids (Pseudotolithus spp) and Galeoids (Galeoides decadactylus). All of these fishes are rather small less than 30 cm in Fork Length).

Some fishing operations very close to the platforms have been carried out by professional fishermen a few weeks before our survey and have shown a quite different population, composed of big fish, mainly Lutjanids, Pomadasyids, sharks, etc.., all of them bigger than 40 cm FL.

Finally we have observed surface schools, some of Sardinella maderensis in open sea and of Chloroscombrus chrysurus around the platforms by day; by night, below the flares, some small schools of pelagic little fish were seen, hunted by big sharks and Lutjanids (up to approximately 1 m FL).

2.3. Effect of sound emissions.

The impact of some noises on pelagic fish concentrated with lights below the R/V Nizery is presented in fig. 3. It is very hard to extract from these experiments very precise result: more or less all the emissions induced a slight decrease of density, particularly with signals at 250 and 500 Hz.

From these informations, the 250 Hz signal has been selected for an other experiment, consisting in switching on and off the sound emission during repeated periods (fig.4). It can be seen that the densities observed are varying according to the signal emissions.

Then, the following step was to obtain confirmation of the tendency of fishes to concentrate near and below the platforms. The results of the four transects along

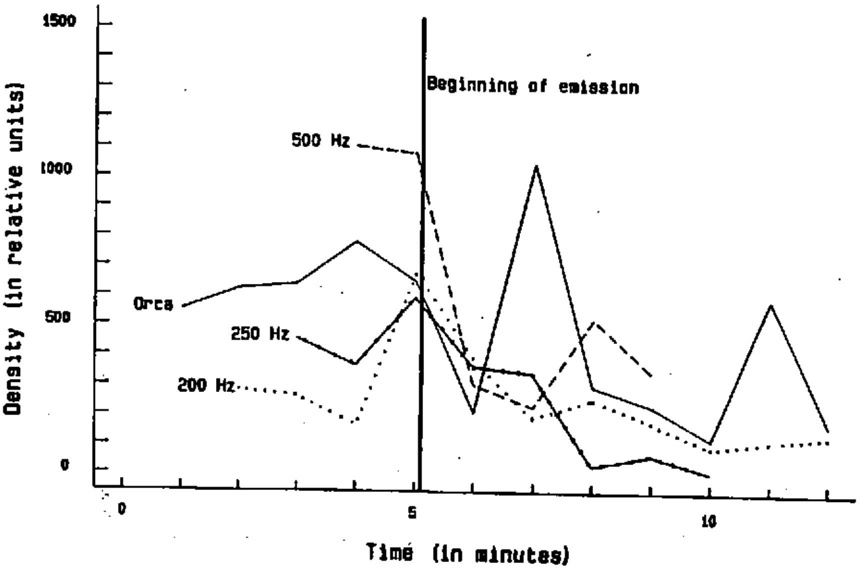


Fig. 3: Effect of several sound emissions on fish density

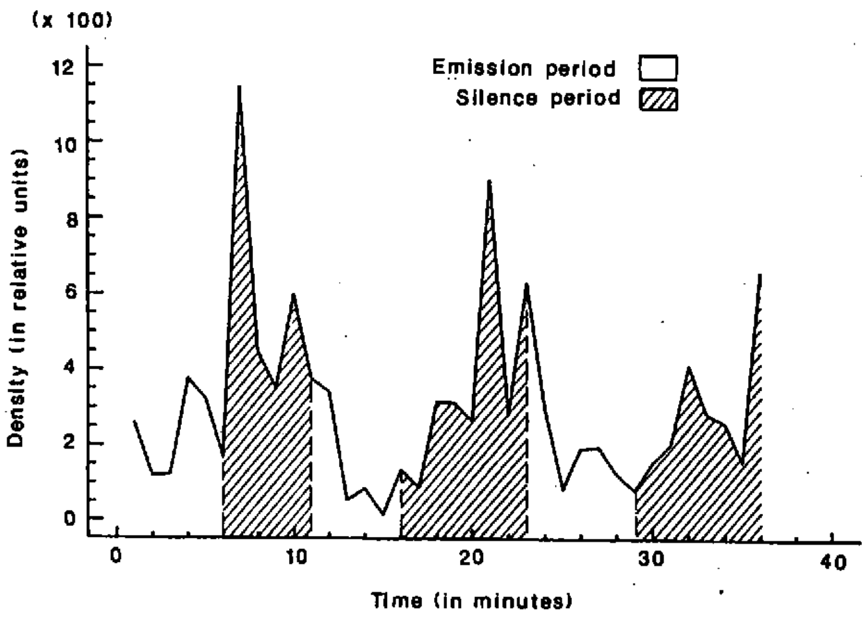


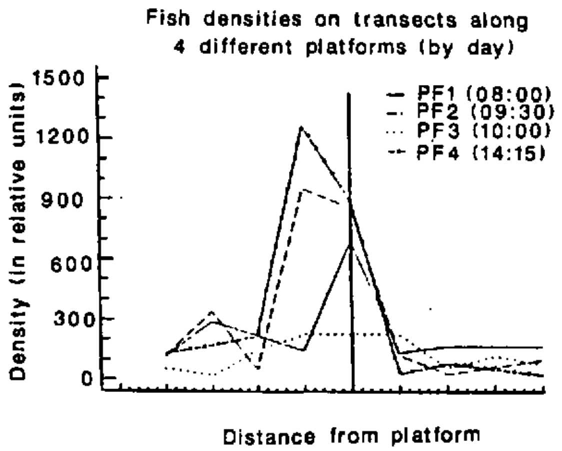
Fig. 4: Influence of a 250 Hz emission on fish density

a platform (fig 5) show a neat "platform effect", the density values being higher in a circle of 0.1 mile around the platform. The main densities are not exactly centred on the platform: this phenomena corresponds probably to a current effect 7 , but no current measurements have been done.

The same transects were performed near a platform while the buoy was emitting sounds recorded from Orca orca. Four measurements were done (fig 6). One can see that by day the already observed "platform effect" is present. Immediatly after the first transect the orca's noise were emitted and an other day transect was carried out seven hours later (at 5 p.m). It is obvious that the noise presents a real repulsive effect. Then by night the transect was repeated twice, at 9 p.m. and 0.30 a.m.: in these two cases the densities were much higher below the platform than in any other place.

2.4. Mapping fish densities around "emitting platforms"

a). By day. The buoy emitting a 250 Hz pure frequency was placed near the platform. The prospection was done following the scheme presented before, but with a single circle at 15 m around the platform, and two perpendicular transects. Results of densities on each 1/2 transect and on the circle are presented in fig. 7. The data show clearly, once more, that by day the artificial noise is a real fish repellent: the fish densities change when the noise begins to be emitted. One can observe that immediatly after the beginning of the emissions the densities decrease near the buoy and increase far from it, while after some hours the density has neatly decreased in every place around the platform, included after 24 hours of emission (unfortunately it has not been possible to do prospections around this platform during that night).



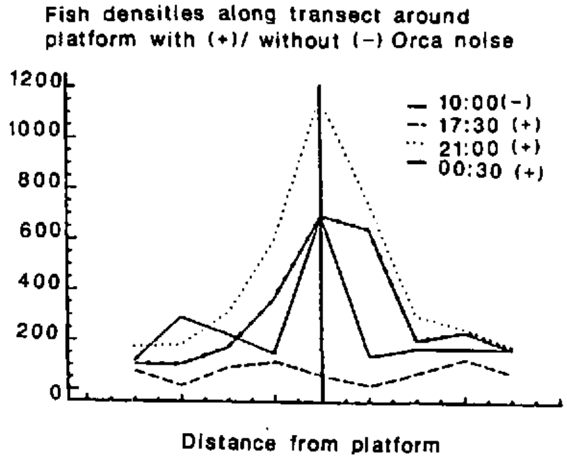


Fig. 5 (left) and 6 (right): impact of the platform structure on the fish concentration without (5) and during (6) sound emissions

b). By night. The noise source in this case is installed below the platform. The global results (fig. 8) show two areas:

- the inner circles do not present interpretable variations in density, specially the smallest one.
- the transect and the 50 m circle show first an increase of biomass immediatly after the sound begins to be emitted, then a slight decrease.

These two observations are not very easy to interpretate, and the data had to be observed in an other way: the evolution of densities on each 2 m layers (fig. 9). In these data neat changes appear, related to the noise: the pelagic densities

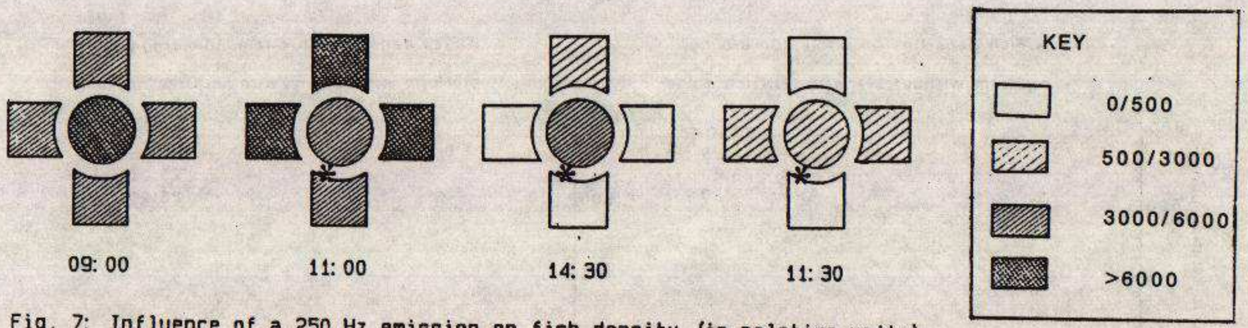


Fig. 7: Influence of a 250 Hz emission on fish density (in relative units) around a platform during 24 h.

* Point of emission

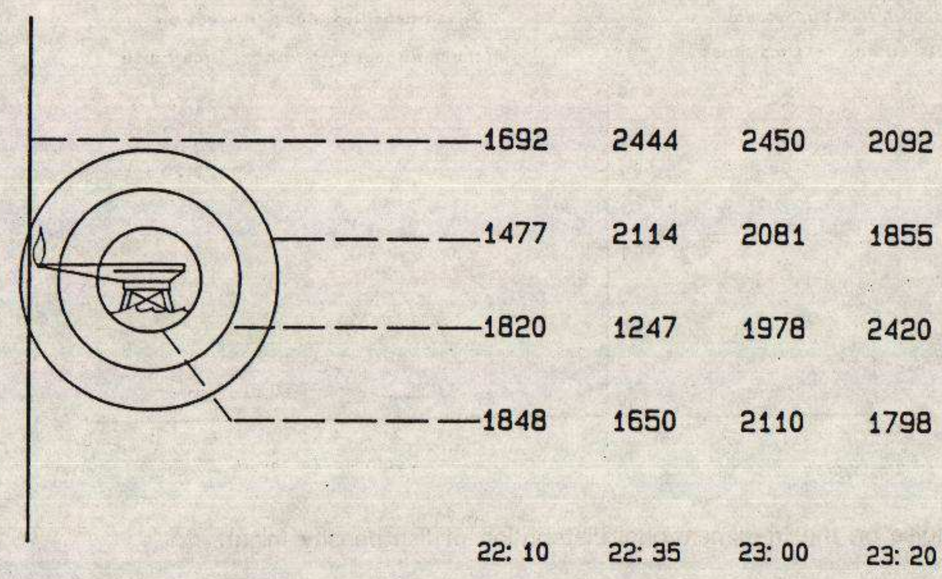


Fig. 8: Influence of Orca noise on fish density around a platform (night)

(from 3 to 8 meters below the surface) highly increase in the outer circle and the transect (fig. 9 c and d), while they decrease in the inner circles where on the contrary the demersal densities increase (fig 9 a and b).

This could be explained by the fact that, by night, two attractive stimuli are existing: the platform itself, influencing the inner circles, and the flare, which influences the outer circles.

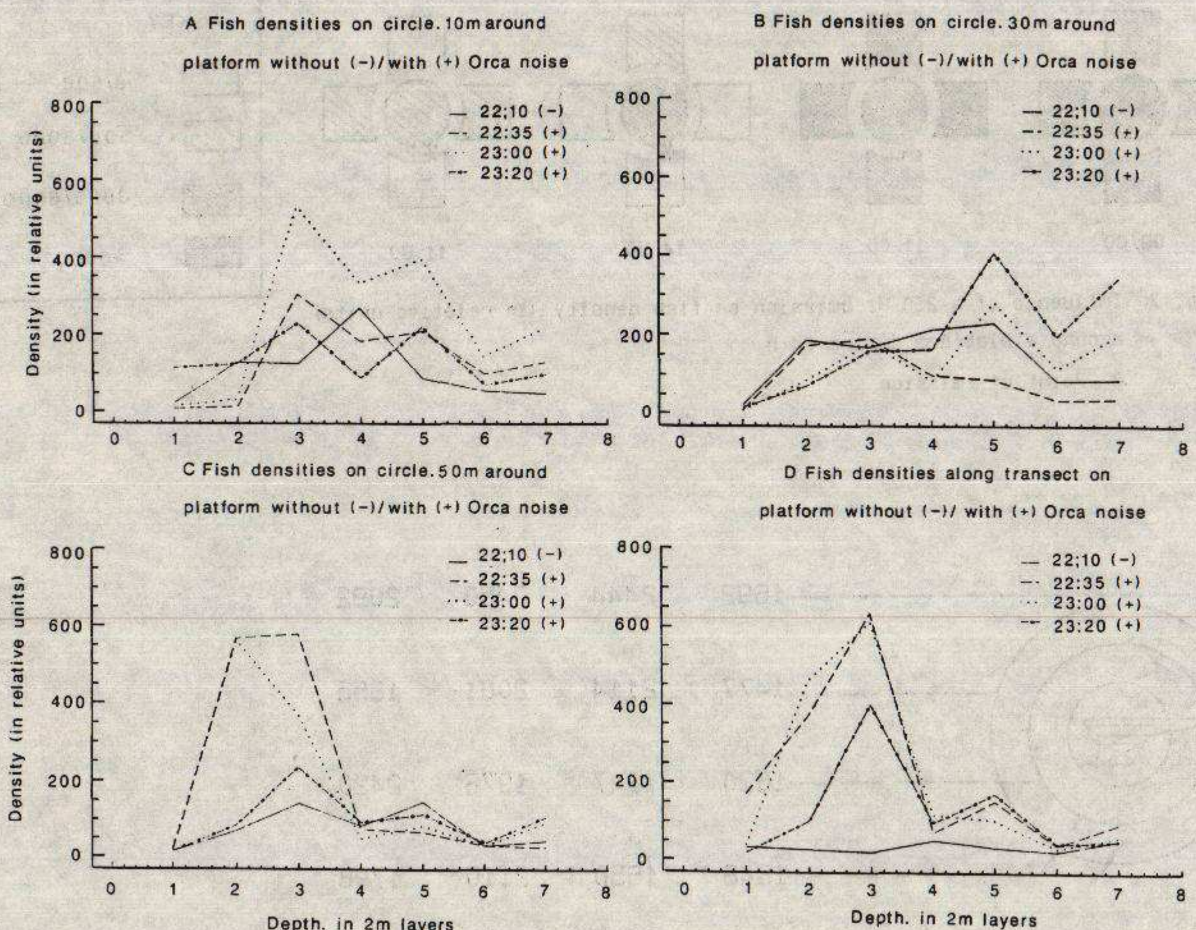


Fig 9: Influence of Orca noise on the tri-dimensional distribution of fish density (night)

3. DISCUSSION

3.1. Density values

Fishes present a positive tropism to platforms by day. Nevertheless this platform effect is rather limitated in space and completely masked when the data are integrated in a longer distance. When observing the night data, we can see a rather similar phenomena, although the samples are too small to permit any statistical analysis. An other point has to be discussed: it seems, according to the data, that concerning the pelagic fish, the attractive impact of the light is more important than the repulsive effect of the noises, as should indicate the fig. 6.

3.2. Fish population observations

The former observations, plus the fishing informations that showed two distinct populations, below the platform and in the total exploitation field, could lead to the following interpretation:

- the principal population of fish in the area is made of small pelagics, such as Clupeids, which do not present any attraction reaction to the platforms by day, and Carangids, with few reactions; they present a rather localized reaction to the light by night (the water was turbide, with visibility less than 5 m).

- Strictly localized very close to the platforms exists an other population, made of big predators, permanently attracted by the metallic submarine structures. It is known [8] that these species usually stay under the protection of a reef or reef-like structure by day and move by night in search of preys. In this case the platform takes place of the reef but, as the flare attracts the preys by night, the predators do not move far from it: they feed on the pelagic concentrations attracted by the light.

3.3. Effect of the noises.

a). Day reactions. Reactions of fish to an artificial noise are immediate and rather important, the fish escapes rapidly from the emission source. Those presenting that reaction are most probably the small pelagic species present all over the area: the big fish which stay below the platform do not leave the protection of the submarine structure.

b). Night reactions. The light attraction appears very strong, and if the fish react to sound emissions, they do not leave completely the area. On the contrary the concentration of pelagic fish become higher below the flare. Considering the big demersal fishes, they present also a reaction to the emitted sounds, and tend to leave the platform, but not so far as the pelagic fishes do, as the highest concentrations of demersal are seen at 20 m to the platform.

In conclusion of these observations, it could be said that the pelagic population reacts to the emissions in concentrating below the light, while the demersal tends to leave the emission place, but staying as close as possible to the platform.

4. CONCLUSION

a) Fish attraction by the light may vary depending on the species: the small pelagic seem much more attracted than the big demersal.

b) A new sound emitted in the sea may have a strong repellent effect, on all the species, but the avoidance reaction differs for the two groups above mentioned. This effect is immediate but vary according to the time: by day the pelagic fish escape radially from the noise source, by night they tend to concentrate below a light. The demersal behaviour is more complicated.

c) almost all of the selected sounds produced avoidance reactions, the strongest ones being with sounds between 250 and 500 Hz, and biological predator noises Orca).

d) the synthesis of the results leads to the conclusion that light, as a stimulus, is much more important than noise, at least when using it as a continuous attractive stimulus, and not as a flash repulsive one. This observation concerns more the small pelagic species than the big demersal.

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