International Council for the Exploration of the Sea

Fish Capture Committee
C.M. 1988/B:24
Ref.H

# BEHAVIOUR OF NORWEGIAN SPRING SPAWNING HERRING IN RELATION TO UNDERWATER LIGHT

by

Arvid K. Beltestad & Ole Arve Misund

Institute of Fishery Technology Research
Fishing Gear and Methods Division
P. O. Box 1964
5024 Bergen
Norway

ABSTRACT

The Norwegian coastal purse seiners, with shallow nets, have experienced difficulties in catching the herring due to their natural behaviour being located too deep during day time and too scattered during night time. Experiments, conducted by FTFI, have shown that scattered congregations of herring may be concentrated by underwater light. When light was switched on underneath the school, the herring immediately rose towards the surface with a speed of approximately 20 m/min. Use of underwater light to manipulate the natural behaviour of herring would increase the efficiency, and consequently the economic benefit for the costal purse seiners.

INTRODUCTION

The Norwegian spring spawning herring stock has increased during the last years. So has also the fishing effort. The fishing is mainly carried out with purse seines along the coastline from Stadt to Lofoten. During day time the herring schools are located in deep waters, migrating to the surface in the evening. Usually the migration of the schools stops at deeper water than 50 metres before they disperse. It is therefore very difficulty to catch these deep schools with shallower nets than 60 - 70 metres. During night time the herring are usually too scattered for feasible purse seining. The smaller coastal purse seiners, with shallow nets, have therefore experienced difficulties in catching the herring and very often they need months to take their quotas.

Artifical light has been used in many countries, especially in Japan, the Mediterranean and in Russia, to concentrate scattered congregated fish (Ben-Yami 1976). In Norway electric surface light is used in the inshore purse seine fishery for sprat and small herring. This fishery is regulated by the Norwegian authority and is only legal in the southern part of the country. Underwater light, widely used in Japan, have advantages over surface light which loses parts of its illumination due to reflection at the surface. However, according to Ben-Yami (op. cit.) some fish species are more attracted by surface light than underwater light and vica versa.

With the aim to increase the efficiency of the coastal purse seiners, the Institute of Fishery Technology Research (FTFI) in 1986 started trials with underwater light to concentrate scattered herring during night and to manipulate the natural behaviour of the herring in a way to make them more catchable.

The trials were conducted during September/October in 1986 and 1987 in the fjords inside Kristiansund. Minor trials were also carried out in the same area during the spawning season.

## EQUIPMENTS

The investigations were conducted with our small 42 feet research vessel M/V "Fjordfangst". The vessel is equipped with sonar (150 kHz Furuno CH-12) and echo sounder (70 kHz Simrad EY-M) for fish recordings. In 1987 the echo sounder was connected to a Simrad QM echo integrator. The calibration and settings of the echo sounder and integrator are described by Misund & Øvredal (1988). A new type of sector scanning sonar (330 kHz Simrad FS 3300) was also tried. Both sonars were connected to a video recorder.

The underwater lamps used were produced in Japan (Shin Nikkar YM-S)(Fig. 1). The voltage is 220 V (AC) and bulbs with 500, 1000 and 2000 W can be used. The lamps can withstand pressure down to 200 metres depth. Upward and downward reflectors of different colours (white, red and blue) may easily be mounted.

## RESULTS

### The 1986 trials

The herring in the area were a mixture of different year-classes (1978 - 83) with a length distribution ranging from 24 to 35 cm. The herring schools were staying close to the bottom or in deeper waters than 200 metres during day time. At dusk the schools migrated towards the surface and stopped at approximately 50 metres depth before they dispersed.

The fishing grounds were searched with echo sounder and sonar for concentrations of herring in the evenings prior to the light trials. Fig. 2 - 5 shows examples of echo recordings from one of the trials. The distribution of the herring, which are rather scattered before the trials, is shown in Fig. 2. The vessel was anchored and the lamps lowered to 10 metres depth and the light switched on. In this example it was used 3 lamps of 500 W each and with blue reflectors pointing downward. Usually the herring reacted by packing and descending 20 to 30 metres when the light was switched on. However, the herring seemed to become gradually accustomed to the light and attracted by it. The depth of the distribution and the density increased very fast (Fig. 3). After 1 1/2 hours the herring were concentrated under the light sources from 50 metres to the bottom (110 metres) (Fig. 4). Even if the light intensity was reduced to a minimum the herring did not react and stayed in the same depth.

A 2000 W lamp with upward pointing reflector was tried underneath the herring concentration. Immediately after the light was switched on, the herring rose towards the surface with a speed of approximately 20 m/min. (Fig. 5). Sonar recordings of this situation (Fig. 6) confirm that most of the herring rose vertically up to the surface. These trials were repeated many times with the same results. Very soon after the light underneath the school was switched off, the herring gradually gathered in the light from above (Fig. 5).

The herring were also attracted by the light when the vessel was drifting, but the concentration and the density do not seem to be so significant as when the vessel was anchored. However, concentrated herring were following the light when the vessel was moving with a speed up to 1 kn.

The 1987 trials

The length distribution of the herring located in the area ranged from 28 to 38 cm. The herring schools stayed close to the bottom in the deepest part of the fjord during day time and migrated towards the surface with a speed of approximately 1 m/min. at dusk. As distinct from the 1986 situation the schools dispersed very close to the surface. During night time it was hardly possible to record the herring on the echo sounder, only on the sonar. At dawn the scattered congregations descended downward to the bottom.

Trials with light were carried out in areas where herring were recorded. The relative biomass of herring during the light trials was measured by means of the echo integrator. The reflected echo energy (Acoustic index) was read for every 5 minute throughout the trials. The acoustic index for each interval was reduced by the reflected echo energy at the start of the trials. The integrator channel was set from 0 to 80 metres. During these trials 3 lamps with 500, 1000 and 2000 W at 5 metres depth were used. After 60 minutes the 2000 W lamp was switched off, than the 1000 W after 65 minutes and from 70 to 75 minutes the voltage on the last light was reduced to 50 V.

Fig. 7 shows the variation in acoustic index and depth distribution with time from 3 trials with underwater light. The herring, which stayed close to the surface before the light was switched on, very soon got attracted by the light. The depth interval increased and after 5 minutes the distribution ranged from 5 to 75 metres. The acoustic index also increased. When the light intensity was reduced, the acoustic index increased at the same time as the depth distribution became narrower. This shows that the herring rose to the surface and that the density became higher when reducing the intensity.

Comparative trials between underwater- and surface light and between underwater light of different colours were also conducted. However, such trials may be biased due to different distribution and density of the herring between each trials.

Comparision between underwater- and surface light is shown in Fig. 8. The same lamps were used in both trials. During the first 25 minutes the acoustic index was higher for underwater than for surface light during the first 25 minutes. This may indicate that herring are faster attracted by underwater light. Other trials during the investigation also confirm this. The depth distribution was much greater with underwater light, which may indicate that this light penetrate to a greater depth.

Trials with different coloured reflectors (white, red and blue) is shown in Fig. 9. The variance between the different trials are too great to establish the colour preference.

Records taken with the sector scanning sonar (Fig. 10), showed that the herring stayed deepest just below the light source where the intensity was highest, and very close to the surface to the side of the light source.

Trials with light underneath the herring schools staying at 110 - 140 metres depth, were carried out during day time. The herring schools immediately rose 20 metres as the light was switched on.

Minor trials with underwater light during the spawning season have shown that pre-spawning herring also get attracted by this type of light.

## DISCUSSION AND CONCLUSION

The difference in the natural vertical migration between the two years may be due to difference in temperature or zoo-plankton distribution.

The investigations have shown that the herring are attracted by both underwater- and surface light. It is reasonable to believe that underwater light is more effective than the sur-face light when the herring are staying deep, because the underwater light have the farthest penetration. On the other hand the surface light may be more effective when the fish are close to the surface. Many trials during this investigation indicate that the herring are faster attracted by underwater light. This is also shown for saithe (Ona & Beltestad 1986).

According to Dragesund (1957) and Ben-Yami (1976) the behaviour of herring towards light varies, and it is difficult to establish a clear behaviour pattern. The different depth distribution and different reactions towards reduced light intensity between the two years in this investigation, confirm this.

However, although there are large variations in the behaviour pattern, underwater light may be a fruitful method for the coastal purse seiners to concentrate dispersed congregations of herring. When the herring schools are staying to deep for shallow nets, the method by lowering a lamp underneath the school and switch on the light during pursing may raise the herring up into the net. This method may also be used to scare the herring away from the opening under the vessel during pursing.

If artificial underwater light could be legalized in the fishery for Norwegian spring spawning herring the smaller coastal purse seiners could be able to take their qouta within reasonable time with an improved economic benefit.

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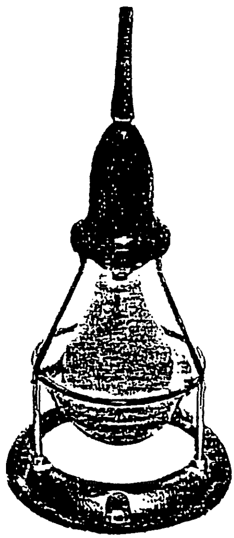

Figure 1. Shin Nikka underwater lamp, type YM-S.

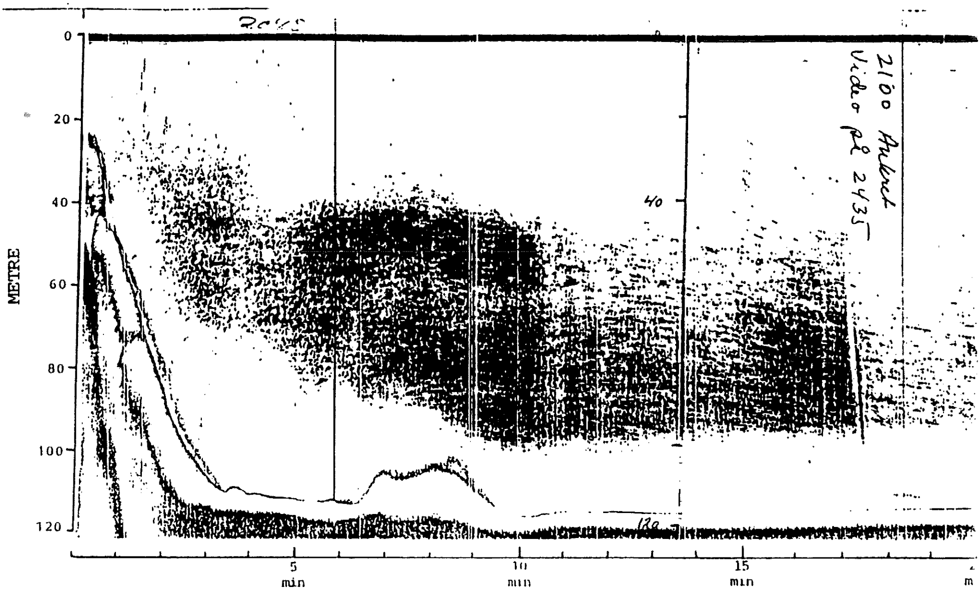


Figure 2. Natural distribution of herring during night time.

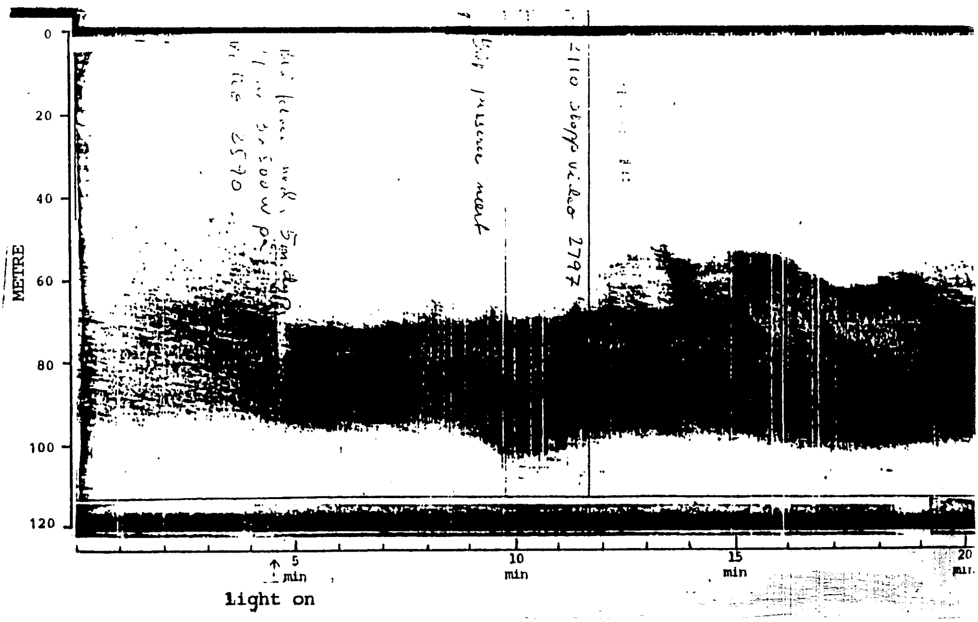


Figure 3. Distribution of herring before and after the light (3 x 500 W)

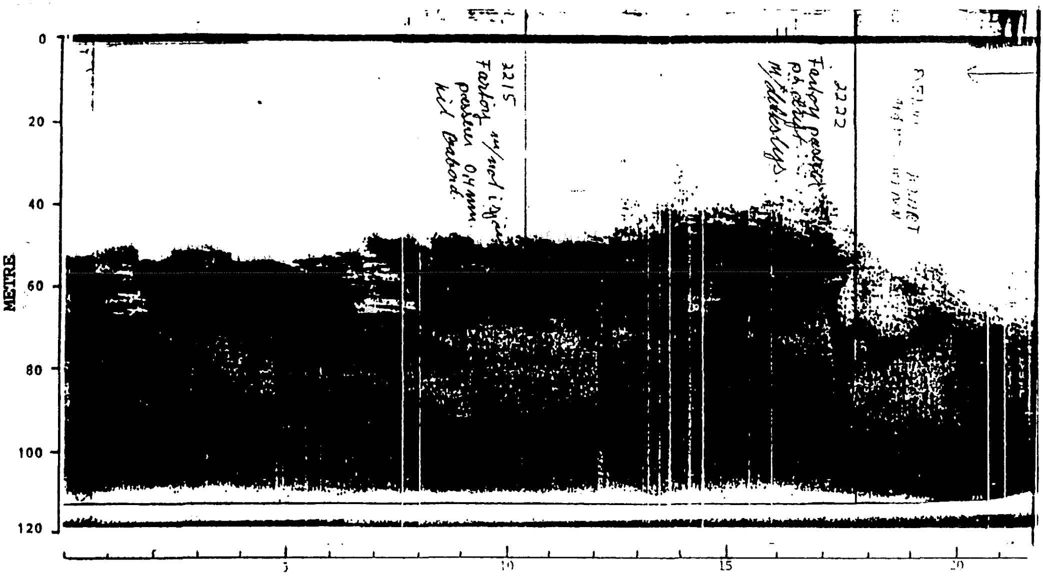


Figure 4. Distribution of herring 1½ hours after the lights were switched on.

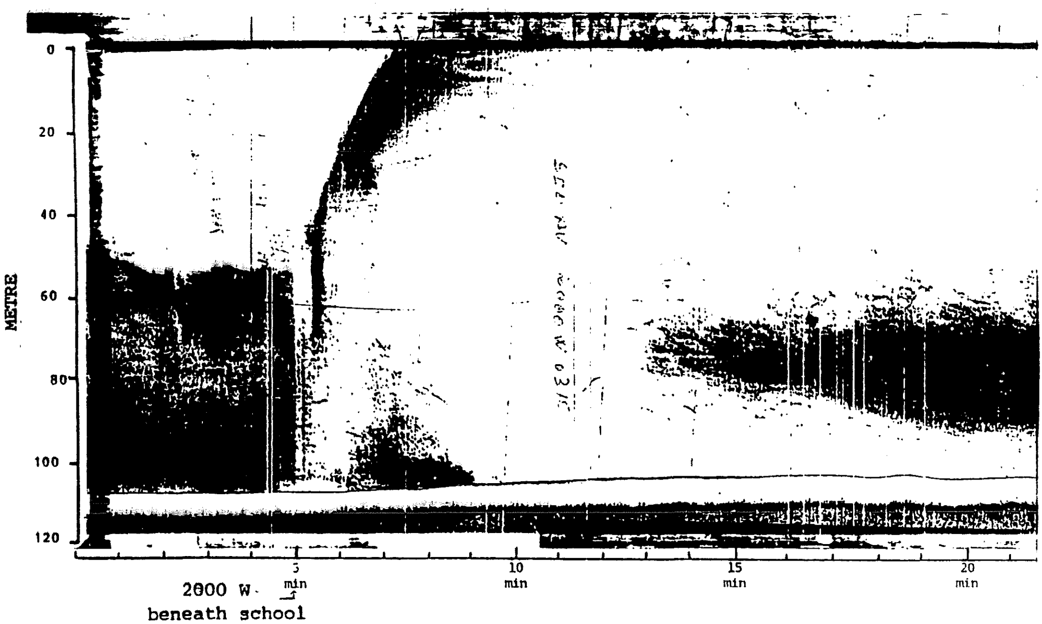


Figure 5. Change in distribution when 2000 W light were switched on beneath the school

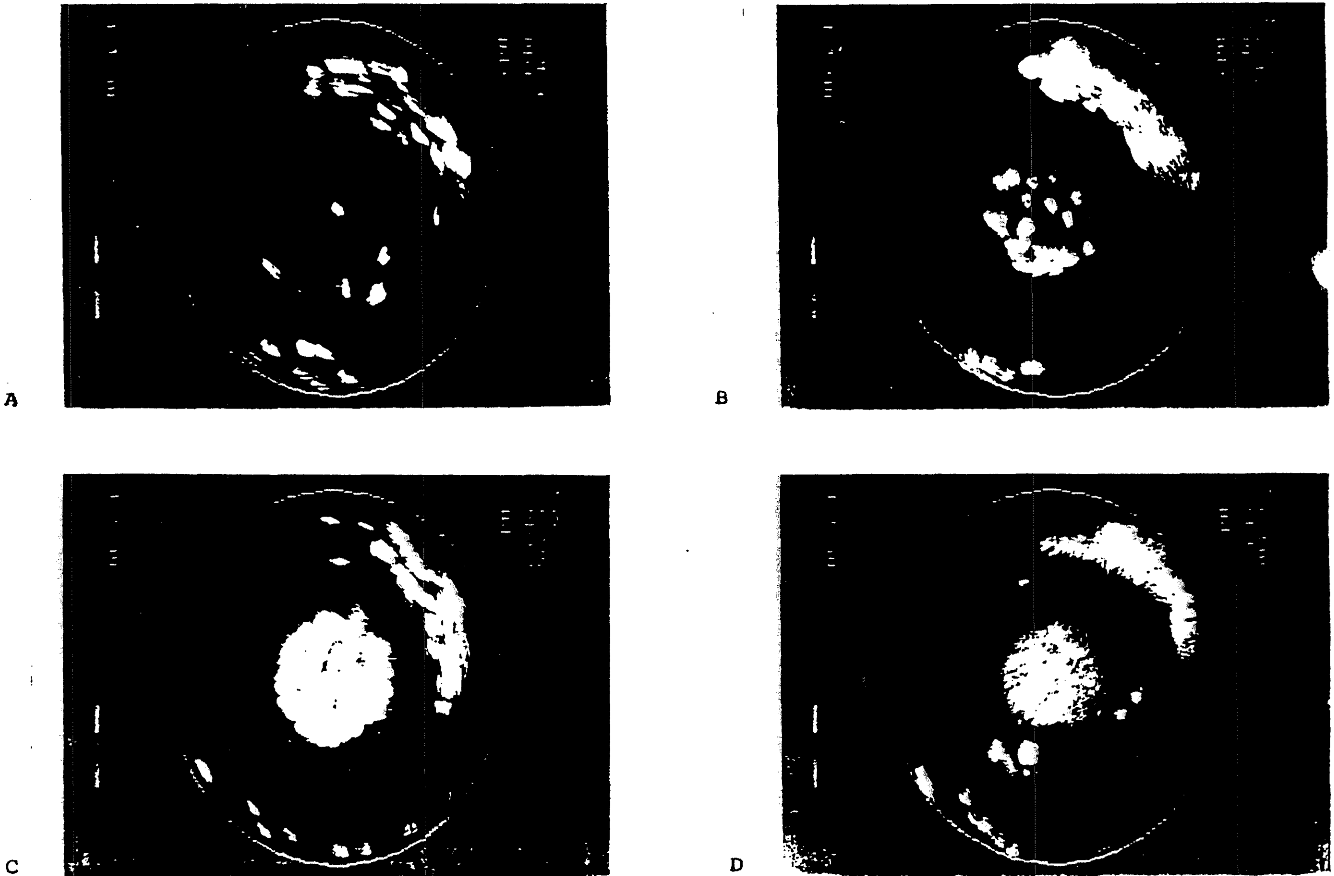


Figure 6. Sonar recordings of herring during the experiments with light underneath the school.
A. The light switched on. B. 1 1/2 minutes later.
c. 2 minutes later. C. 3 minutes later.

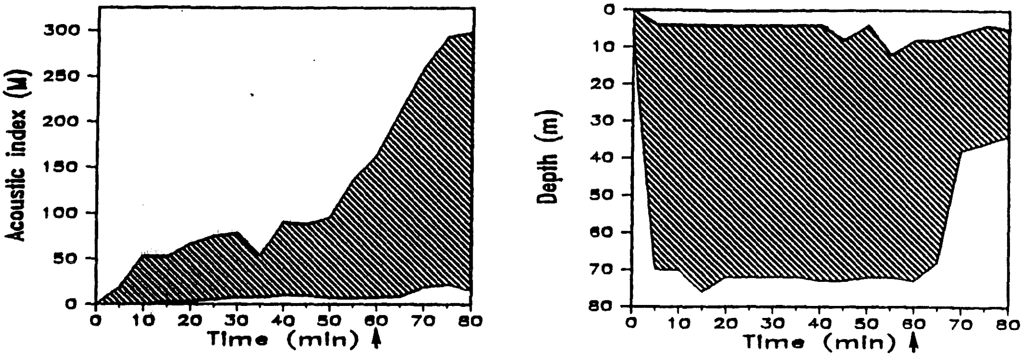


Figure 7. Interval of variation for reflected echo energy (left) and depth distribution (right) during light trials. ▲ Start of reducing light intensity.

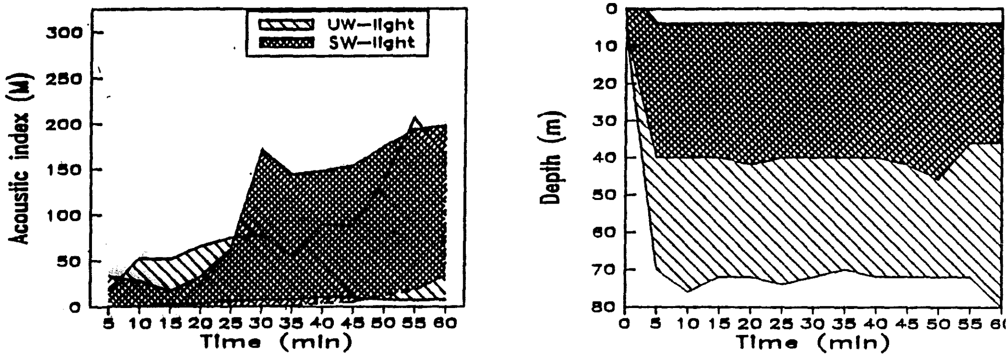


Figure 8. Interval of variation for reflected echo energy (left) and depth distribution (right) during comparing trials by surface (SF) and underwater (UW) light.

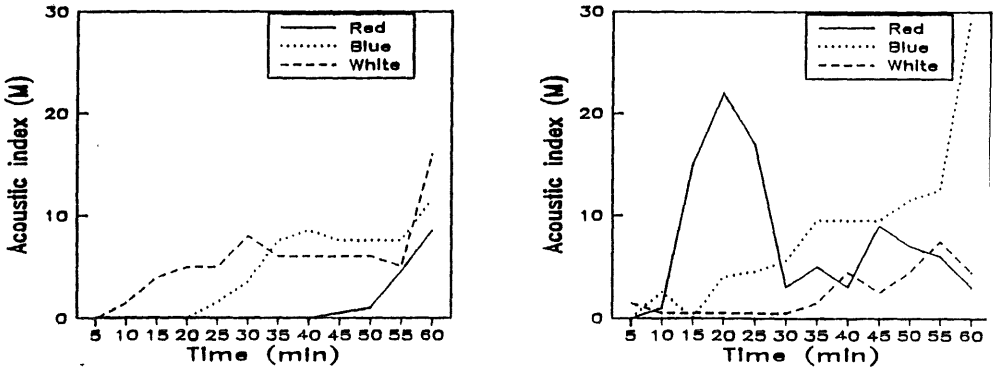


Figure 9. Reflected echo energy during two trials with underwater light of different colours.

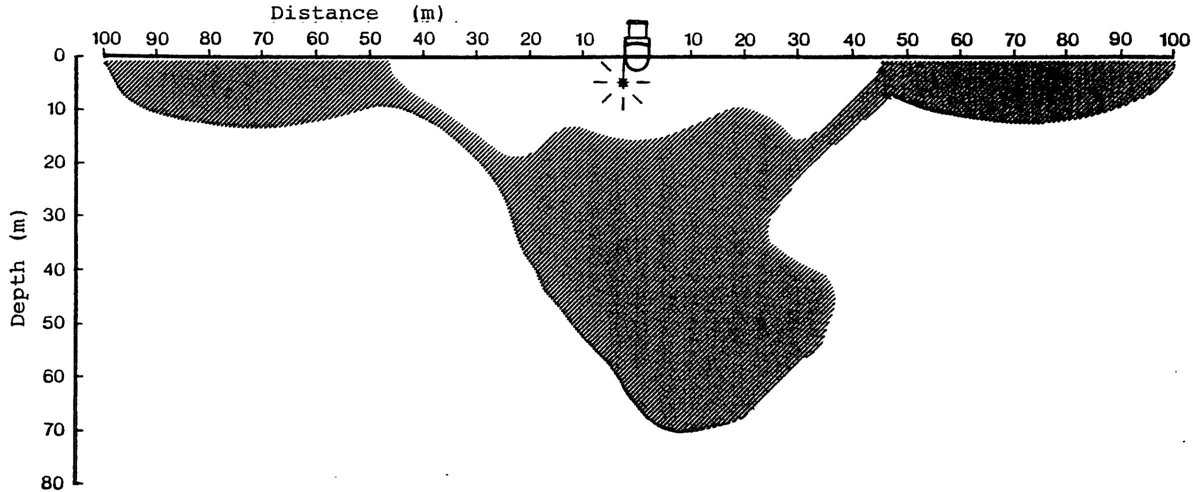


Figure 10. Distribution of herring in a vertical section around the light sources as recorded by SIMRAD FS 3300 during trials by underwater light.