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DAY/NIGHT VARIATION IN FISH DIRECTIVITY IN THE TRAWL OPENING

By

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ABSTRACT

Still photographs of fish in the mouth area of a bottom trawl were taken by a downwards-oriented automated strobe camera mounted near the headrope. Fish angles relative to the towing direction were measured. Fish were significantly less polarized by night than by day, and in the daytime photographs less polarization was seen at low fish densities than at higher. The results are discussed with regard to fish herding patterns and potential escapement beneath the fishing line of a trawl.

INTRODUCTION

The purpose of a bottom trawl's groundgear is to form a smooth interface between the trawl and the bottom. Its functions include helping to deter damage to the trawl from rough bottom, and to herd groundfish into the net. In commercial fishing operations the groundgear can be fine tuned to suit the bottom type and the targeted fish species. In many trawl sampling situations, however, a wide variety of bottom types and fish species have to be accommodated, and consequently many compromises have to be made. One is that the groundgear has to be chosen for the roughest of the sampling areas. As a result of this, escapement under the groundgear can be a serious potential problem. In Norway's annual Barents sea trawl sampling program for groundfish this was identified as a problem, and in an effort to address it the original standard bobbin-type groundgear was replaced with a "rockhopper" footrope, which seemed to offer reduced escapement, especially for smaller fish (Engås and Godø, 1989). Nonetheless, even after this change to the survey trawls' specifications, concerns over escapement below the footrope remained. The rockhopper groundgear used during these surveys has ample space between its discs for escapement even of big cod, and on rough bottom the gear will also momentarily snag and jump as it moves over the bottom, creating opportunities for fish collecting in front of it to escape under the trawl.

Also, different herding effects on different size groups and species of fish may be expected under the varying illumination conditions experienced night and day, shallow and deep, and with varying seasons. This will also potentially bias samples and, accordingly, stock estimates.

The present paper examines fish behaviour in front of the groundgear in an attempt to describe the situation regardless of depth or time of day. One problem with the most common method used to observe fish around trawl gear is that either observations must be restricted to depths and times of day when ambient illumination is sufficient for observation with video cameras, or artificial illumination has to be used, which may influence the behaviour of the fish. Acoustics and infrared (IR) illumination are other options, but available acoustic systems do not offer adequate resolution, while reliance on IR illumination strongly limits observation range. The photographic system with automatic exposure and strobe illumination used in this investigation has a distinct disadvantage in only giving static images at intervals, but its influence on the behaviour of the fish should be minimal, it has very good resolution, and it offers satisfactory observation range.

MATERIALS AND METHODS

The experiments were carried out on a cruise with R/V"Johan Hjort" in March 1994 on the east Finnmark shelf between Tana fjord and Vardø. The standard Norwegian survey trawl was used, a "Campelen 1800" trawl with a rockhopper groundgear (Engås and Godø, 1989). The measured vertical opening was 4.5 m, average towing depth was 85 m, towing speed was 3.5 knots, and tow durations were approximately one hour. Two experimental tows were made, one starting near noon and the other at midnight, local times. The cod end was not closed due to high fish abundance in the area. A Photosea 1000, 35 mm under water photographic camera was used with a Photosea timing device and an Osprey strobe light. All components were mounted within a protective stainless steel cage, which was hung under the top panel of the trawl, 0.75 m behind the center of the head line (Figure 1). The 28 mm focal length water corrected NIKON lens had an opening angle of 50° horizontally and 35° vertically, giving a ground coverage of 3.6 m sideways and 2.5 m in the towing direction, equalling 9.2 m^2 at 4 m distance on the optical axis. The area covered included the center of the groundgear (visible in the bottom of the pictures) and the area in front of it. The timer was set to make its first exposure at about the time the trawl settled on the bottom, and after that to make one exposure every 30 seconds. The exposed film (Kodak Tmax 400ASA) was developed immediately following each haul.

On shore the negatives were analyzed in a simple image analysis system. The system comprised a SONY CCD V-700 Hi8 consumer video camera with a SONY negative holder mounted in front of the lens, a SCREEN MACHINE frame grabbing board installed in a PC and a simple image analysis program (SCREEN MEASUREMENT, Prague University).

When analyzing the pictures, the first 5 minutes of bottom time were discarded. Fish angles were measured relative to the vertical orientation of the negative, which was assumed to be parallel to the towing direction. Only the angles of clearly identifiable fish images were measured. It was not possible to distinguish with certainty between images of cod and haddock. 92 usable frames containing identifiable fish images were obtained from the daytime tow, with a total of 978 fish for an average of 10.6 fish per frame, while four negatives contained no discernible images of fish. Similarly, the nighttime tow yielded 108 frames containing 1173 clear fish images for an average of 10.9 fish per frame, while 6 frames bore no fish images.

RESULTS

Figures 2 and 3 show the total frequency distribution of fish angles in the day and night haul respectively. During the daytime haul the fish were clearly more polarized in the towing direction than at night. This is illustrated by the fact that in the daytime haul just one fish had an angle greater than 90° relative to the trawl direction, while at night there were 50 such fish. Also, the frequency of observed angles decayed more steeply in the day haul (Figure 2) than in the night haul (Figure 3).

Figures 4 and 5 are plots of mean fish angles in each picture versus the number of fish per picture in the day and night hauls respectively. Dispersion bars about each mean angle are also plotted. In the daytime haul mean fish angles were substantially higher in those frames containing three or fewer fish compared to frames containing four or more. Although no tests for statistical significance have been carried out, these differences are striking, and there is little overlap of the dispersion bars for the two fish per frame and three fish per frame cases versus those for four or more fish per frame. There was no subsequent decrease in average angles with increasing numbers of fish per picture. In the night time haul (Fig. 5) there were no apparent relationships between mean fish angles and numbers of fish per picture.

Figures 6 and 7 show echograms from the day and night hauls respectively. In the daytime recordings fish traces are clearly identifiable, while at night hardly any fish could be identified in the bottom expansion of the echogram. However, the fish densities in the mouth area of the trawl as seen in the photographs seemed to be about equal day and night. Tows with the cod end closed at the same location showed 81 % haddock (modal length 41 cm) and 19 % cod (modal length 46 cm).

DISCUSSION

The observed fish densities in the two hauls were similar by day and night, as were the fishing area, gear parameters, and operational procedures. It can therefore be postulated that the observed differences in fish angle distribution reflect biologically significant differences in behaviour. A pronounced difference was found in day/night orientation relative to the towing direction. In the daytime the fish were distinctly polarized in the towing direction, while at night this polarization was much less pronounced. This is in good accordance with results reported by Glass and Wardle (1989) and Walsh and Hickey (1993). The results are hardly surprising, as it is to be expected that fish rely to a large extent on visual cues, if available, while avoiding trawl gear.

It may, however, seem surprising that the average number of fish per picture is identical day and night. This may either indicate that fish density, distribution patterns, herding effects, and holding time in front of the groundgear are the same day and night, or that combined variations in these parameters cancel each other out. It is not possible to resolve this question from the present data alone, nor could Engås and Ona (1990) in a study using acoustic techniques to study day/night fish distribution patterns within the mouth of a trawl. However, if we assume that overall fish availability and abundance in the test area were about the same by day and by night, then the similar fish per frame counts must be due to the interaction between herding effects and the rate of fish turnover in the mouth. The reduced polarization observed at night in this study would suggest that holding times in the mouth should be less than in the daytime, or in any case no greater, thus nighttime herding effects must be at least as strong in order to compensate. Results reported by Engås and Ona (1990) and Walsh (1991) support the notion that nighttime catching efficiency and catch rates, at least for cod, are not substantially worse than in the daytime. While some pieces of the puzzle are still missing, it appears that even though the differences in angular distribution reflect the impact of reduced visual information on fish orientation and response to trawl gear, other stimuli or factors in the fishing situation compensate.

Recent experiments (present authors, unpublished) with collection bags mounted behind and below the fishing line suggest that with low fish densities in front of the groundgear the escapement under the gear is greater than with high fish densities in front of the gear. This could be because at low densities each individual will have more space to search for escape opportunities. Also, when large numbers of fish are present, each may concentrate more on orienting in accordance with surrounding fish and less on seeking its own path away from the gear. Our daytime observations support this conjecture, since when many fish were present they tended to be more polarized in the towing direction, and with each other, than when only a few were present. Whether this situation leads to more escapement cannot be determined from the present data but the possibility of a connection between escapement, local fish density, and visual conditions must be investigated further.

The echo recordings showed a totally different picture day and night, but the photographs from the trawl opening were very similar in terms of fish density. There are at least two possible explanations. At night, when virtually no fish traces were discriminated on the echo recordings, fish could be herded to the sides by the ship approaching, and then herded back again by the doors. Alternatively, at night the fish could be staying too close to the bottom to be detected by the echo sounder. The first explanation would require that the fish were more sensitive to an approaching ship at night than in the daytime. With primarily day active fish like cod and haddock this explanation does not seem particularly likely, which lends support to the second hypothesis.

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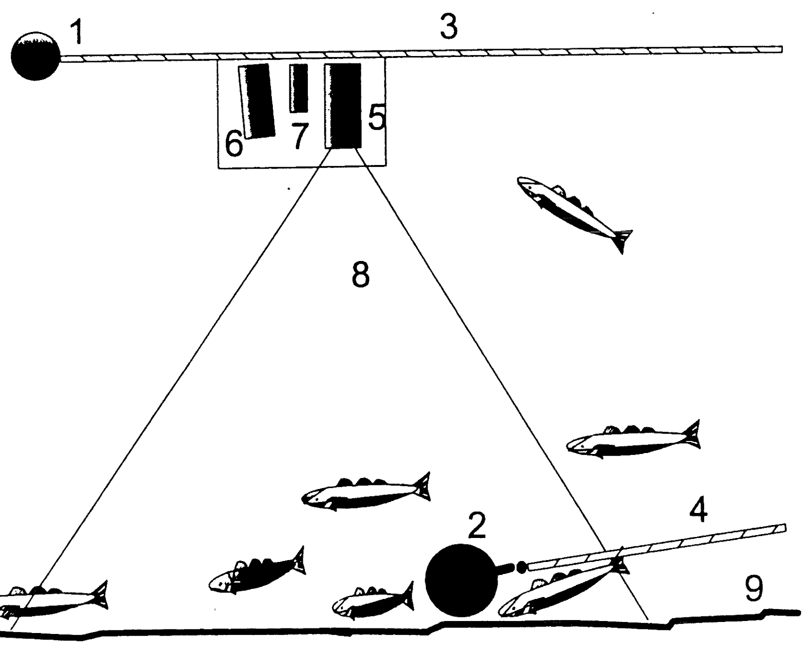

Figure 1. Schematic view of the observation situation. 1) Trawl headline; 2) Ground gear; 3) Top panel; 4) Bottom panel; 5) Camera; 6) Strobe; 7) Timer; 8) Camera angle.

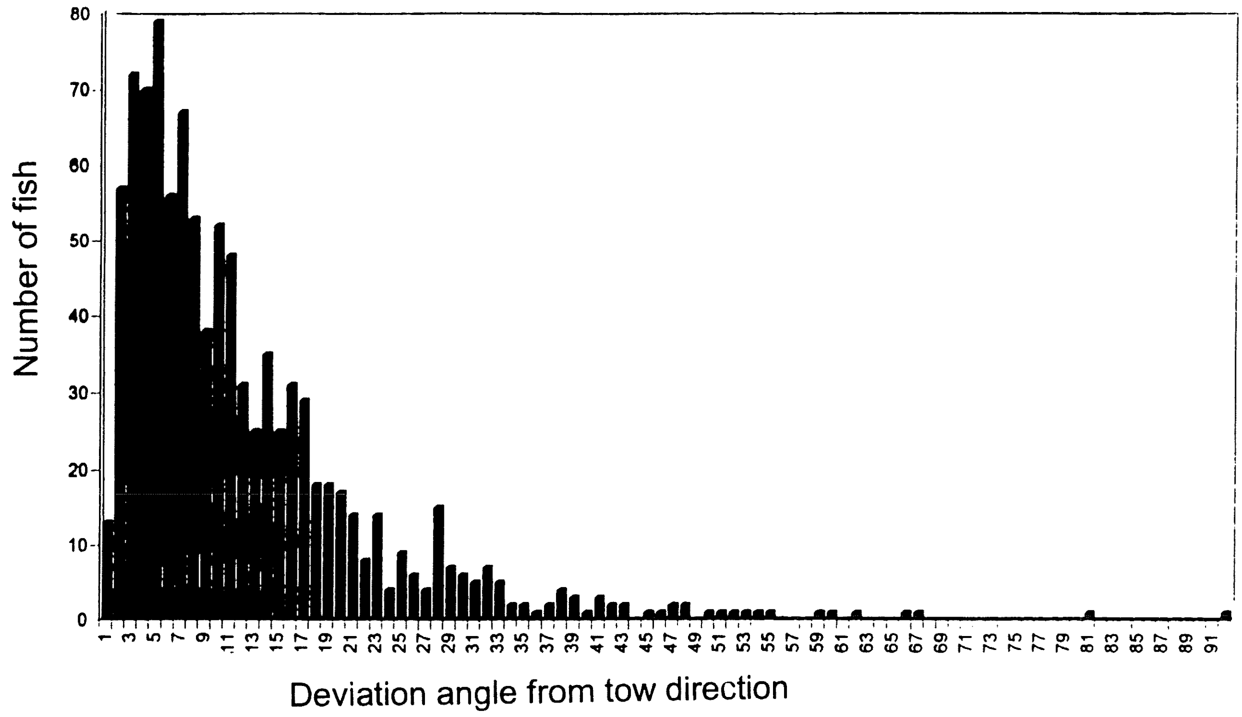

Figure 2. Angular deviation from tow direction. Number of fish per degree (°) of deviation. Daytime situation. Note that Y-axis scale differs from figure 3.

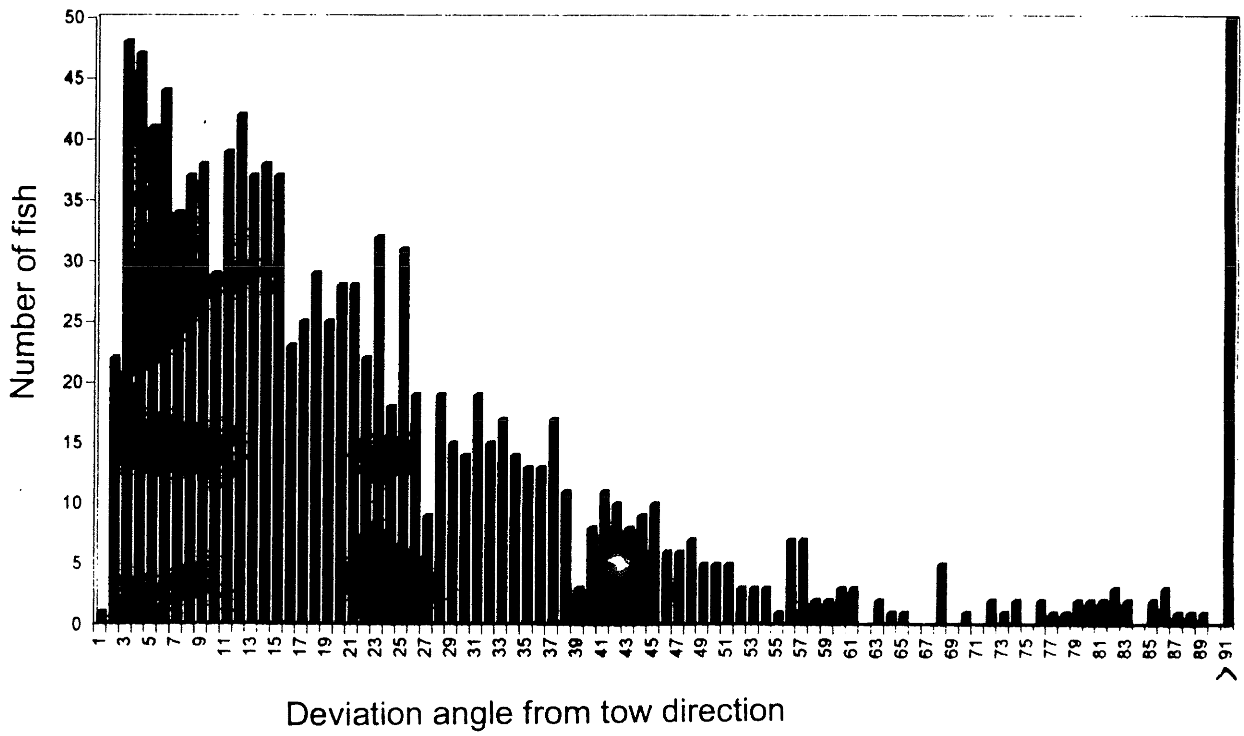

Figure 3. Angular deviation from tow direction. Number of fish per degree (°) of deviation. Night-time situation.

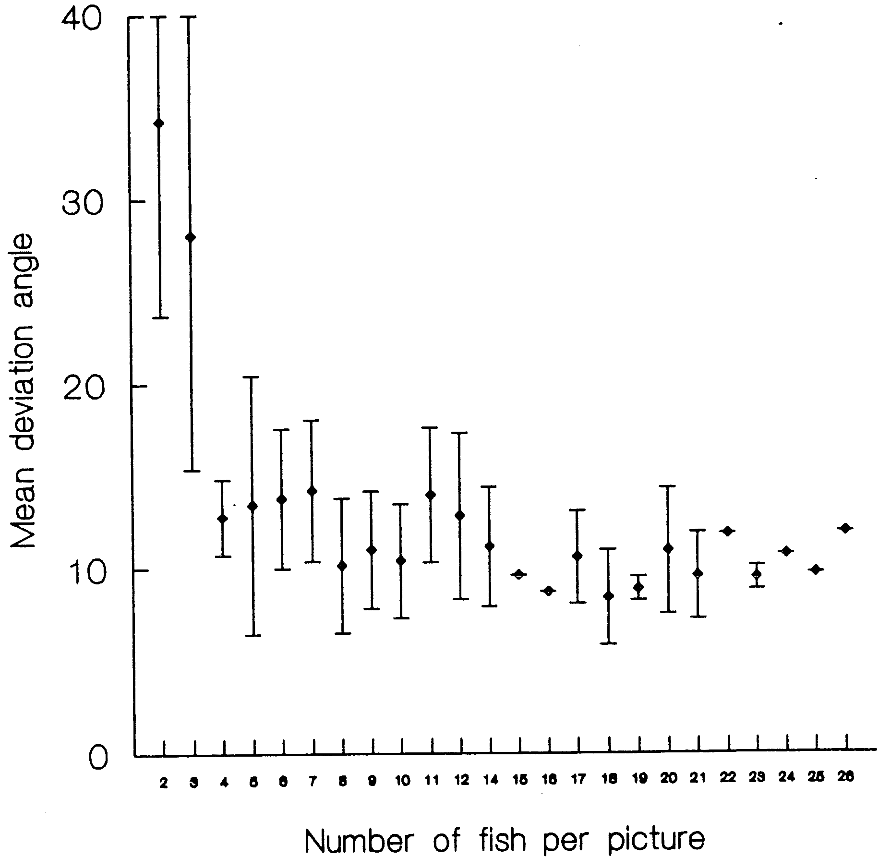

Figure 4. Mean angular deviation from tow direction with increasing number of fish per picture. Daytime situation.

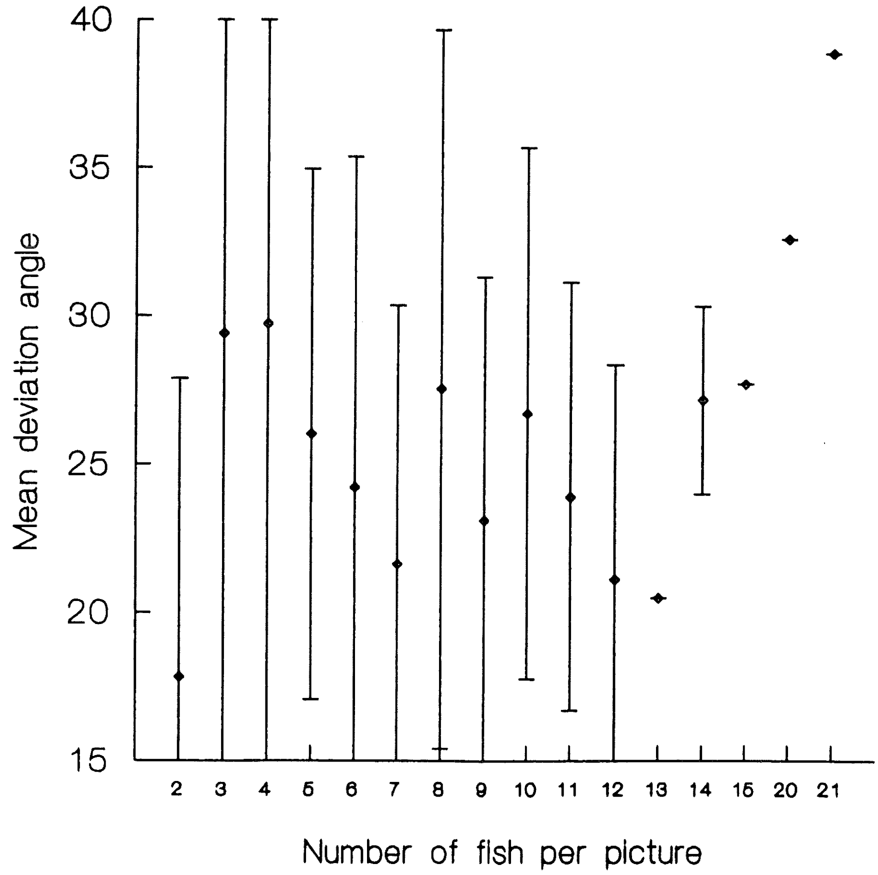

Figure 5. Mean angular deviation from tow direction with increasing number of fish per picture. Night-time situation.

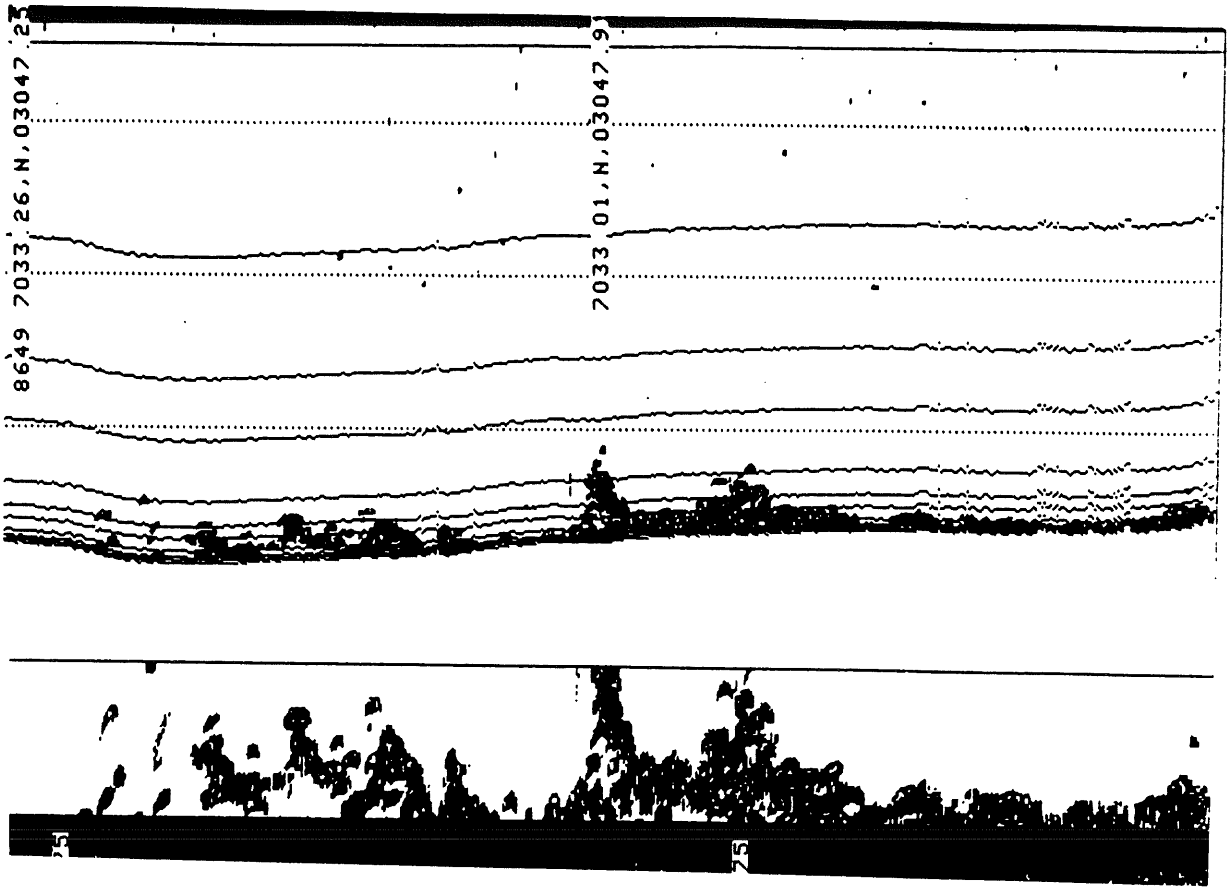

Figure 6. Echogram from the day haul. Good recordings of cod and haddock.

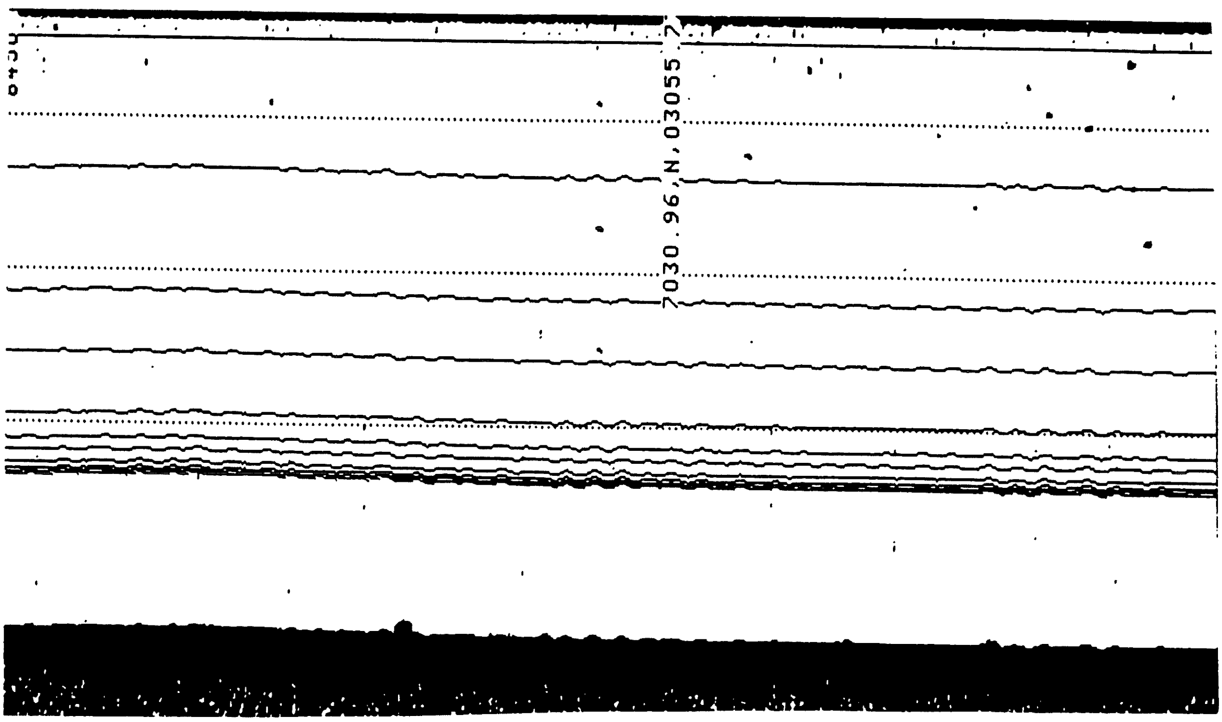

Figure 7. Echogram from the night haul. No fish recorded.