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A HIGH-SPEED VIDEO RECORDING SYSTEM FOR *IN-SITU* STUDIES ON SMALL-SCALE DISTRIBUTION OF ZOOPLANKTON AND ICHTHYOPLANKTON; PRELIMINARY RESULTS ON THE DISTRIBUTION OF PLANKTON IN THE BORNHOLM BASIN (CENTRAL BALTIC)

Abstract

A new device is described for *in-situ* studies on small-scale distribution of invertebrate- and ichthyoplankton. A highly sensitive CCD-Camera is integrated into the cod-end of a standard high-speed plankton sampler of the GULF III type. Video images of plankton organisms are transmitted in real time to the ship board unit together with CTD and oxygen data. First data are given on the small-scale distribution of zoo- and ichthyoplankton from the Bornholm Basin (Central Baltic).

INTRODUCTION

The potential value of using video based instruments for the study of zooplankton abundance, distribution and behaviour has been reviewed recently by STRICKLER & al. (in press). One of the main advantages compared to classical net sampling methods is the increase in spatial resolution that can be achieved by *in-situ* recording systems. This is of special importance for resolving distribution patterns on ecologically relevant scales.

Small scale patchiness of zooplankton organisms defined as fine-scale (m-range) and micro-scale (cm-scale) by HAURY & al. (1978) plays a significant role for the first feeding and survival of fish larvae (LASKER & al., 1970; LASKER, 1974). HAURY & al. (1978) give some examples of the patchy horizontal distribution of various zooplankton groups (appendicularians, amphipods and predominant copepod species) on a 10m-scale obtained by a LONGHURST-HARDY-plankton-recorder, where there was a clear relation between patchiness and physical factors, such as temperature changes at a near-surface tow and internal waves at the thermocline. OWEN (1981) investigated the vertical micro-scale patchiness of microzooplankton by means of a specially constructed micro-patch sampler and found a high variation within the mixed surface layer and within the pycnocline characterized by a chlorophyll maximum. The ecological significance of patchiness is evident in the prey-predator relationship and thus in the efficiency of energy transfer through the food-web.

Improved methods are needed to achieve the required resolution of spatial distribution and co-occurence of planktonic predator and prey organisms.
As introduced by FROESE & al. (1990) our working group is developing video based recordering systems for studies of abundance and distribution of invertebrate plankton as well as ichthyoplankton. The present paper provides a description of the state of development of our high-speed ICHTHYOPLANKTON RECORDER, including some considerations on the spatial resolution to be achieved.Preliminary results from a test tow in the Bornholm Basin (Central Baltic) are presented.

MATERIALS AND METHODS

The Video Recording and environmental sensing system

A first description of the system has been presented by FROESE & al.(1990). Basically a highly sensitive video camera (THETA-Systems HTMX-87) is integrated into the cod-end of the standard German high-speed sampler "Nackthai" (NELLEN & HEMPEL, 1969). The camera produces 50 individual video fields per second (one field comprising only the odd or even line numbers of the full frame and thus including half the information of the normal video image).
The video information is transferred in real time by a telemetry unit via a single conductor cable to a conventional personal computer and video recorder on board of the ship. The telemetry unit concurrently transfers data (depth, conductivity, temperature, oxygen, external and internal flow) which are acquired through a standard serial interface and stored on the hard disk of the PC. The PC is equipped with an interface for inserting the environmental data into the video images.

Spatial resolution of the system

During normal operation, the GULF III-type samplers are towed at a speed of 5 knots; water and organisms are entering the sampler correspondingly at 2.57 m/sec. This speed, together with the video field frequency of 50 Hertz gives a maximum theoretical horizontal resolution in towing direction of 5.14 cm.The degree of integration in the plane across towing direction is given by the mouth area of the sampler of 0.0314 m^2. These figures indicate the spatial resolution to be achieved when assuming that smearing within plankton nets is of minor importance (PIPE & al.,1981). The organisms depicted on each image represent the content of 0.6 l of water *in-situ*.

The resolution of the hydrographical structures is limited by the speed of transfer of environmental data. Within the CTDO-probe used in our instrument (ECO 093; manufacturer ME, Germany), analog data are digitized and transferred in three 8 bit-bytes at 1200 Baud. Transfer of data, decoding the bytes and calculating physical values takes 0.6 seconds for each set of the above mentioned six sensors. For individually allocating video images to environmental data this means that every thirty image a new set of data is valid (see fig. 4). From the beginning of the tow, each incoming data set is given a running number, which is inserted in the upper left corner of the video image and stored together with the image. This number makes it possible to individually identify images and to assign corresponding environmental data. For convenience, environmental data may also be inserted into corresponding video images (see examples fig. 13).

Conditions of test tow

The ICHTHYOPLANKTON RECORDER was deployed from RV "Alkor" on 11 occasions in the Bornholm Basin in July 1991. In order to investigate the fine-scale distribution on both the horizontal and vertical plane, oblique tows including horizontal steps were conducted (see example in fig.3). The shooting speed during oblique phases of the tow was below 0.5 m/sec, while towing speed of the ship was 5 knots. During these first trials the sampler was operated without codend. Taxonomic identifications of recorded organisms could be verified by checking net samples from comparative bongo tows.

Evaluation of video images

The vast amount of data provided by the video system (3000 images per minute of tow) requires some kind of automatic analysis. For this purpose a semi-automatic image analysis system is employed. Due to technical problems, the present preliminary evaluation had to be based on manual analysis, however, and is therefore restricted to selected parts of one test tow only.
This tow was made at 55°36'N 15°15'E during night time and covered a depth range of about 40 m.

Two strategies were adopted for analysis, one for the evaluation of the overall depth distribution of plankton organisms obtained from the oblique phases of the tow, and a second for describing small-scale horizontal distribution patterns.

Oblique phases of the tow were combined to cover the whole depth range from 1.6 to 42.1 m (see labels a to f, fig. 3). Copepods were counted from every thirtieth image corresponding to the succession of the environmental data sets (fig. 4, next page). This way a total of 712 images were examined for copepods.

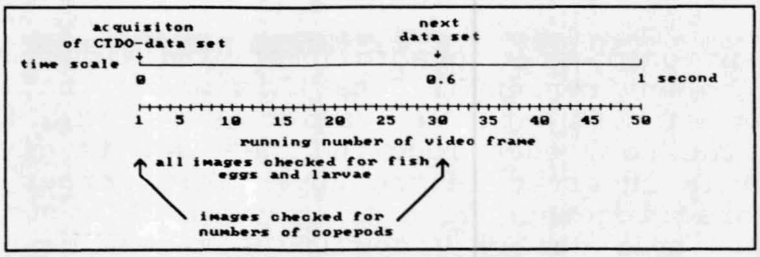

Fig.4: Scheme of the evaluation of stored video images for vertical distribution of copepods and fish during oblique phases of the tow (see fig. 3)

The maximum and the average vertical spacing between analyzed images were 0.3 m, and 0.12 m, respectively. All remaining images inbetween succesive environmental data sets were examined during slow motion of the video tape for fish eggs and larvae and the counts were summed up to give a total number for each series of thirty images.

For analyzing the horizontal variability in copepod abundance, three series of 630 consecutive images each were chosen from horizontal parts of depth track at 5m, 10m and 15m , respectively (labels H1 to H3, fig. 3). According to the towing speed of 5 knots each image series covers a towing time of 12.6 seconds and a distance of 32.4 m.

Results

Hydrographical features

Depth profiles of temperature, salinity and density are given in fig.5, the oxygen profile in fig. 6, respectively. There is a strong thermocline at about 10 m depth. Arrows in fig. 5 and 6 point at the variation of environmental paramters during the horizontal phases of the tow. Within the warmer well-mixed surface water, oxygen content is close to saturation, decreasing parallelly to the temperature profile down to 70% saturation in 42 m depth.

Depth distribution of plankton

A total of 7 fish larvae and of 168 fish eggs were counted from the oblique parts of the tow considered for this analysis. Fish larvae were of the clupeid type and, confirmed by bongo net samples, identified as sprat. The fish eggs had a mean diameter of 1.5 mm and could also be identified from bongo net samples as sprat eggs. Individual specimens are depicted on the video print outs in figure 11.

Depth distributions are given in fig. 7. While sprat larvae were encountered in fairly low numbers in the warm, well-mixed surface layer only, sprat eggs were distributed over the whole depth range covered and were concentrated below 20m. The maximum concentration was three eggs within a thirty image interval.
The towing distance along the oblique track was about 1.5 m during this intervall and the volume searched amounted to about 18

litres.
For copepods the abundance values presented in fig. 7 refer to single images which correspond to 0.6 litres of water. On this scale a rather high variability is obvious. In the upper 15 m depth range peak values of above 120 copepods were observed per image corresponding to above 200 per litre. The abundance decreased over about one order of magnitude for peak values in the deeper part of the sampled range (below 30m).

Small-scale horizontal distribution

From the horizontal towing tracks some pronounced patchiness in the copepod distribution becomes obvious on usually less then the m-scale (fig. 8-10). In the 5 m depth stratum the largest patch with a peak concentration of more than 200 copepods per image (corresponding to more than 330 specimens per litre of water) extended horizontally over about 23 images containing more than 50 copepods each. This corresponds to a patch size of about 1.2 m. The visual appearance of such a con-centration can be estimated from the video printout in fig.11.

Patchiness at the deeper two horizontal strata is of similar appearance with decreasing peak concentrations within the patches.

Conclusions

Our present optical system has been adapted to the size range of fish eggs and larvae. The quality of the images allows at least for general taxonomic differentiation and provides a basis for automatic image analysis. Laboratory trials showed that modifying the background within the optical unit- which is black in the current configuration - gives images of fish larvae, where also pigmentation patterns can be identified. For the size range of copepods the images obtained from the current configuration can only give a rough idea of the type of organisms. It is envisaged to adjust a second system to this smaller size range. The restriction iin the range of organisms that can be handled by a single optical unit is mainly due to the given resolution of highly sensivitive CCD-sensors. With the high speed of improvement of electronic equipment it might be a question of some few years only to get video sensors with a higher resolution and thus to be able to increase the size range to be covered simultaneously. Reducing the minimum size to be resolved may increase, however, also vibration problems. We will therefore test different modifications of suspension of the sampler on the cable and within the optical unit.

With the described ICHTHYOPLANKTON RECORDER which will be further optimized we are aiming towards a better insight into distribution patterns of fish larvae and their prey organisms. The occurence of fish larvae in strata with high copepod patch abundances can even be detected during on-line observation of the video recordings. This gives the opportunity to identify relevant layers while the recorder is under tow.

Studies on details of distributions can be done later from the video tape and will employ image analysis systems. From these, at least counts and size measurements can be obtained automatically at present. The spatial resolution of the system in its current configuration is beyond the upper margin of comparative devices for distribution studies (e.g. LONGHURST-HARDY-Plankton Recorder). Compared to classical net samples it is a clean method. Formalin will be used only for the conservation of the total sample, taken along with the video-recordings. Conserved samples will only be used for the verification of taxonomic identifications from the video-images.

Acknowledgments

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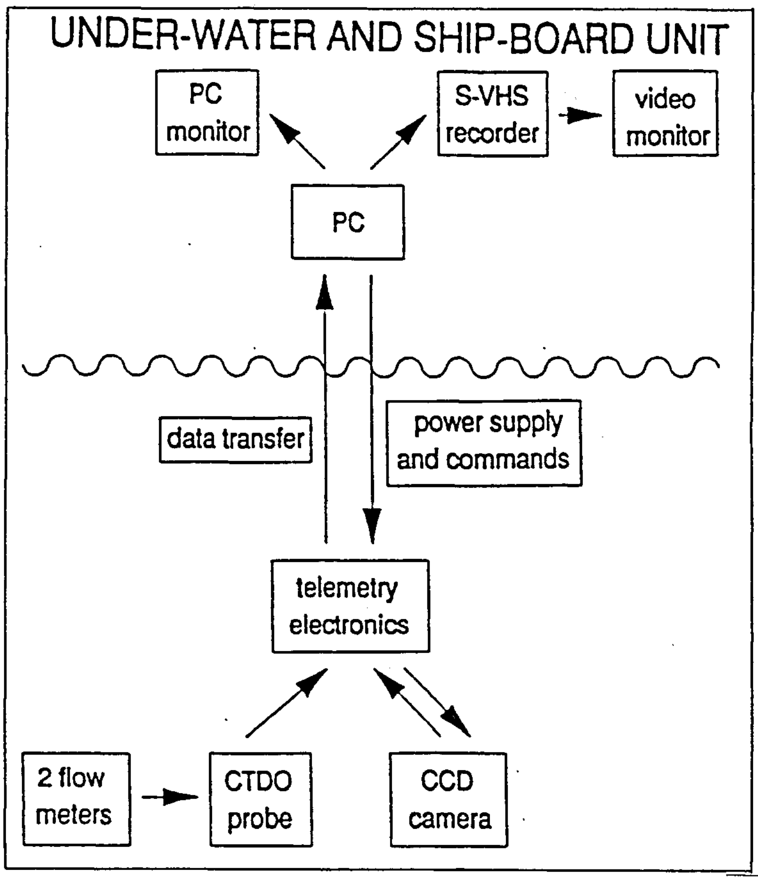

Fig. 1: overall configuration of the system

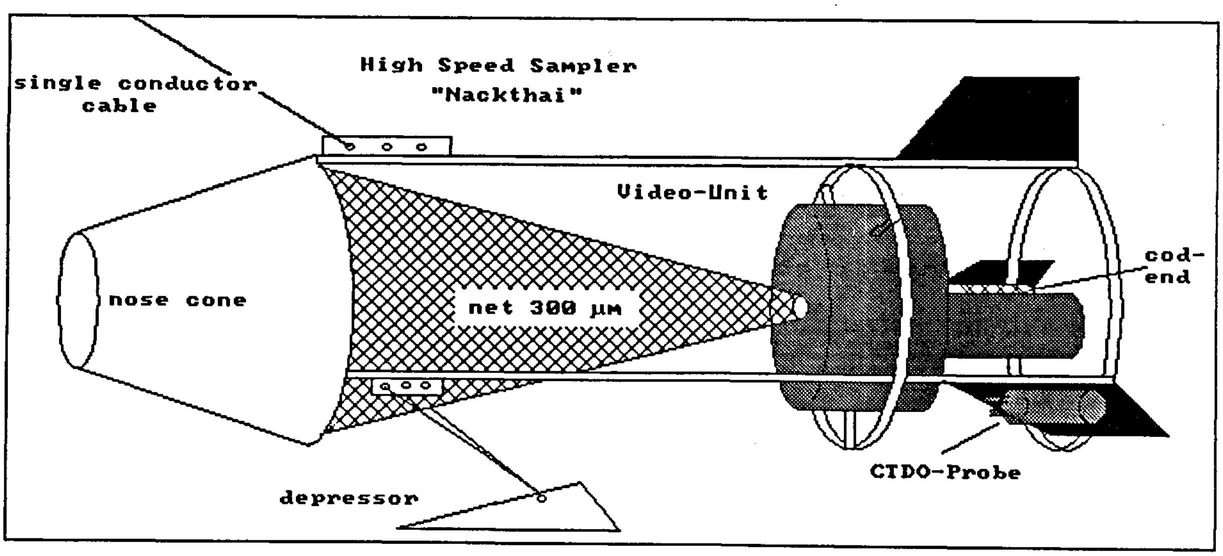

Fig. 2: schematic drawing of the underwater system

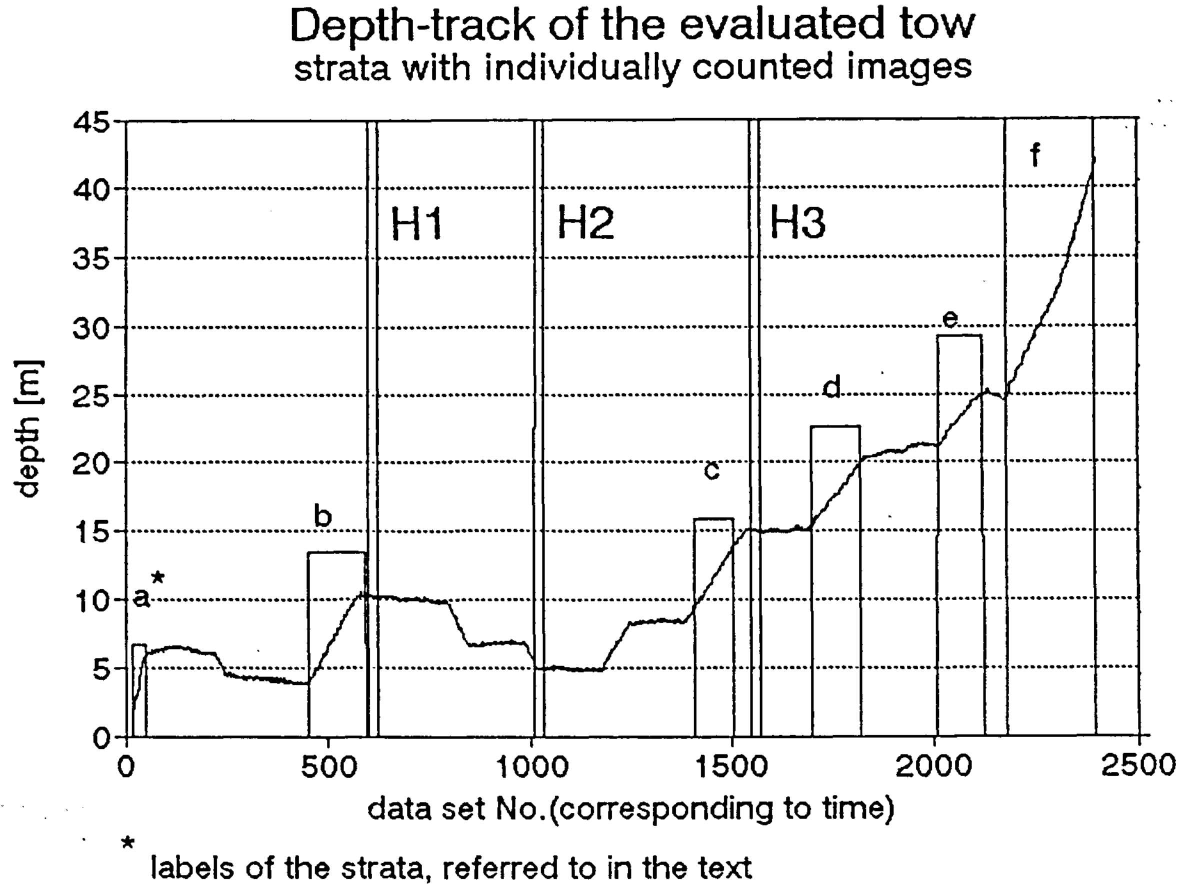
Depth-track of the evaluated tow
strata with individually counted images
H1
H2
H3
a*
b
c
d
e
f
depth [m]
data set No.(corresponding to time)
* labels of the strata, referred to in the text

Fig 3:

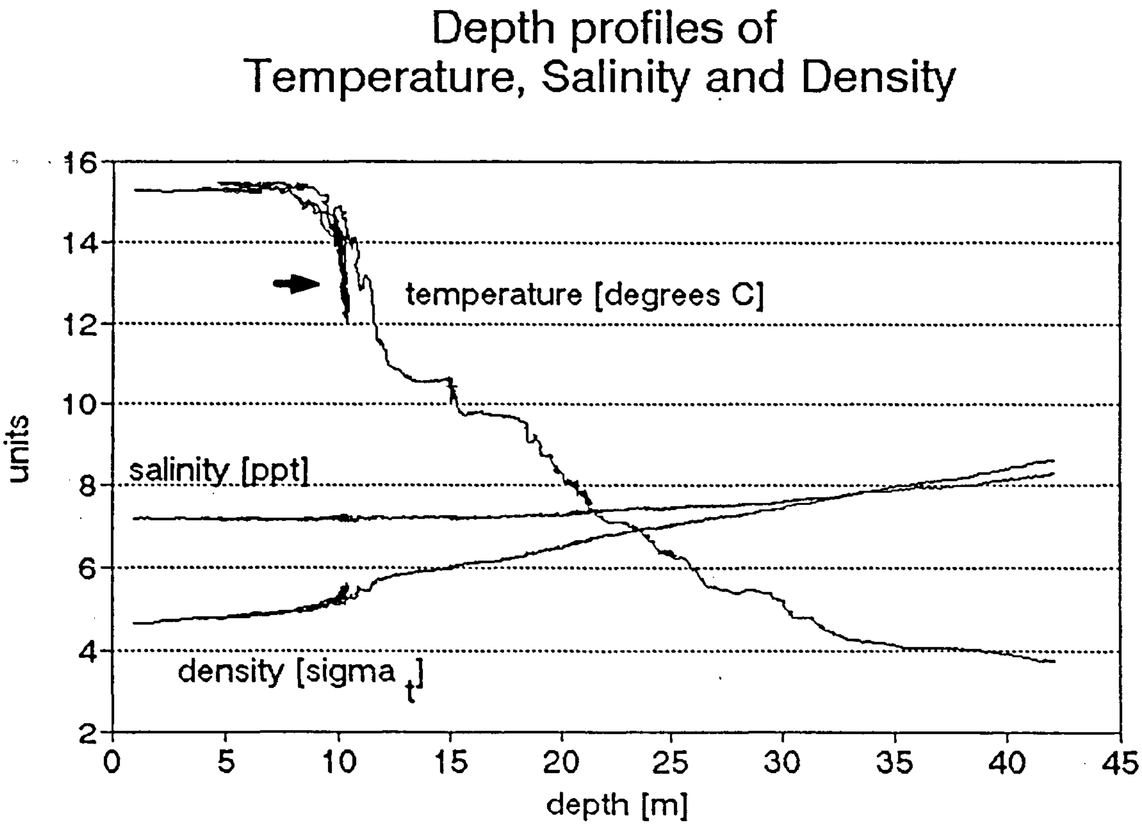
Depth profiles of
Temperature, Salinity and Density
temperature [degrees C]
salinity [ppt]
density [sigma t]
units
depth [m]

fig. 5

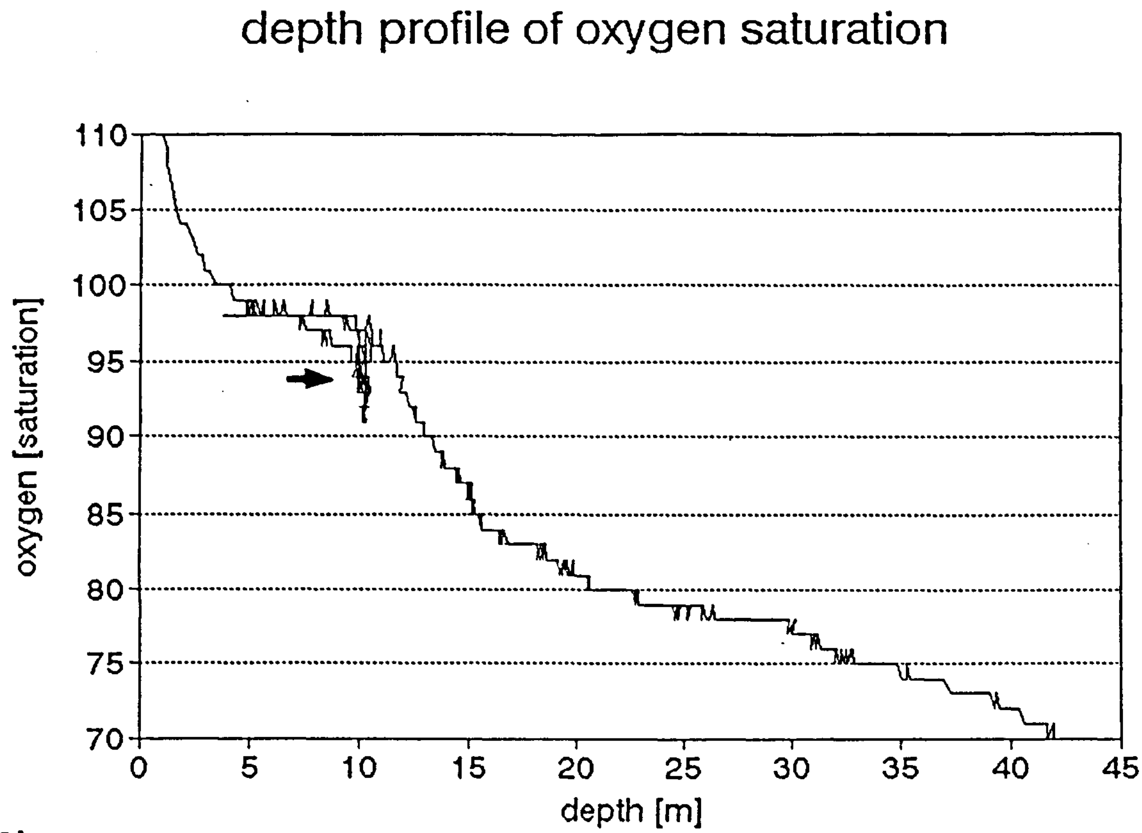

fig. 6

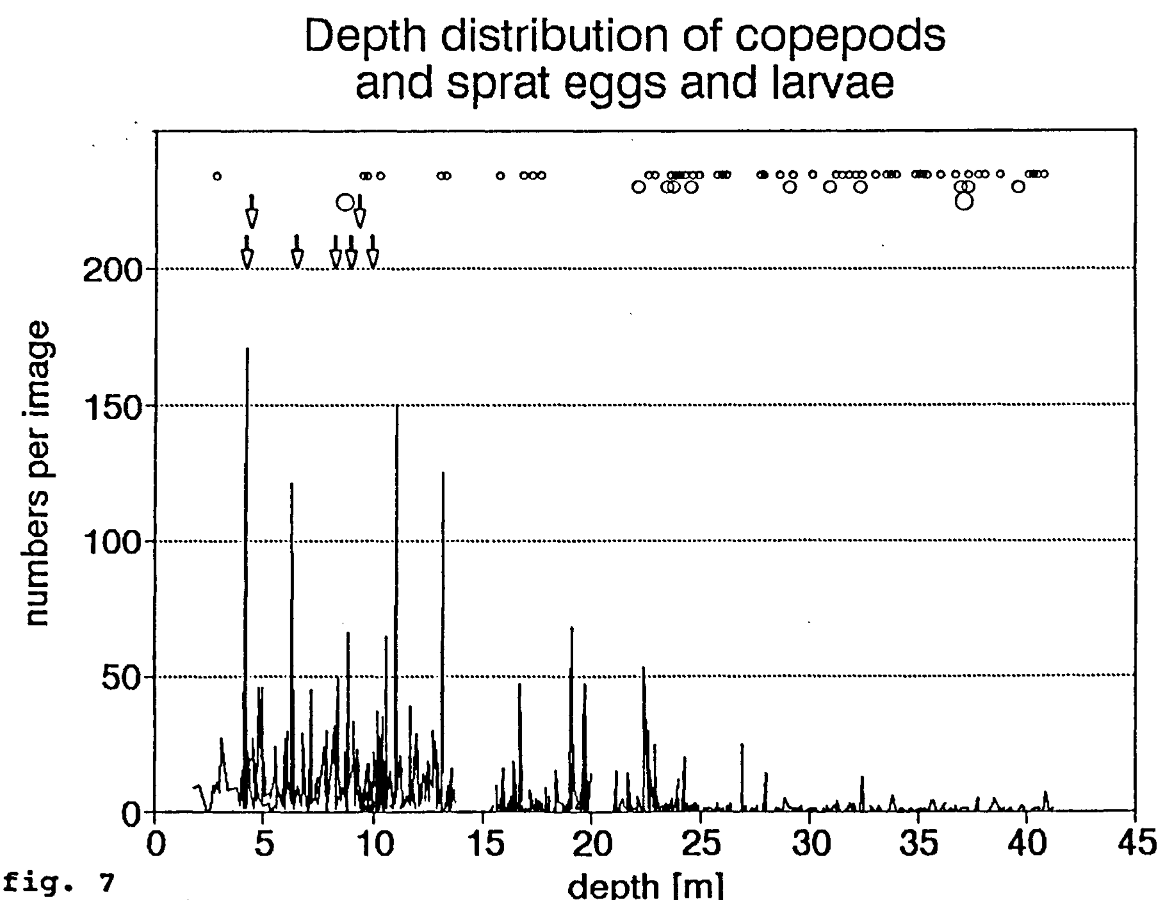

fig. 7
symbols in the upper part:

↓ encounters of sprat larvae

○ encounters of 1 sprat egg within a 30 image interval

○ encounters of 2 sprat eggs within a 30 image interval

◯ encounters of 3 sprat eggs within a 30 image interval

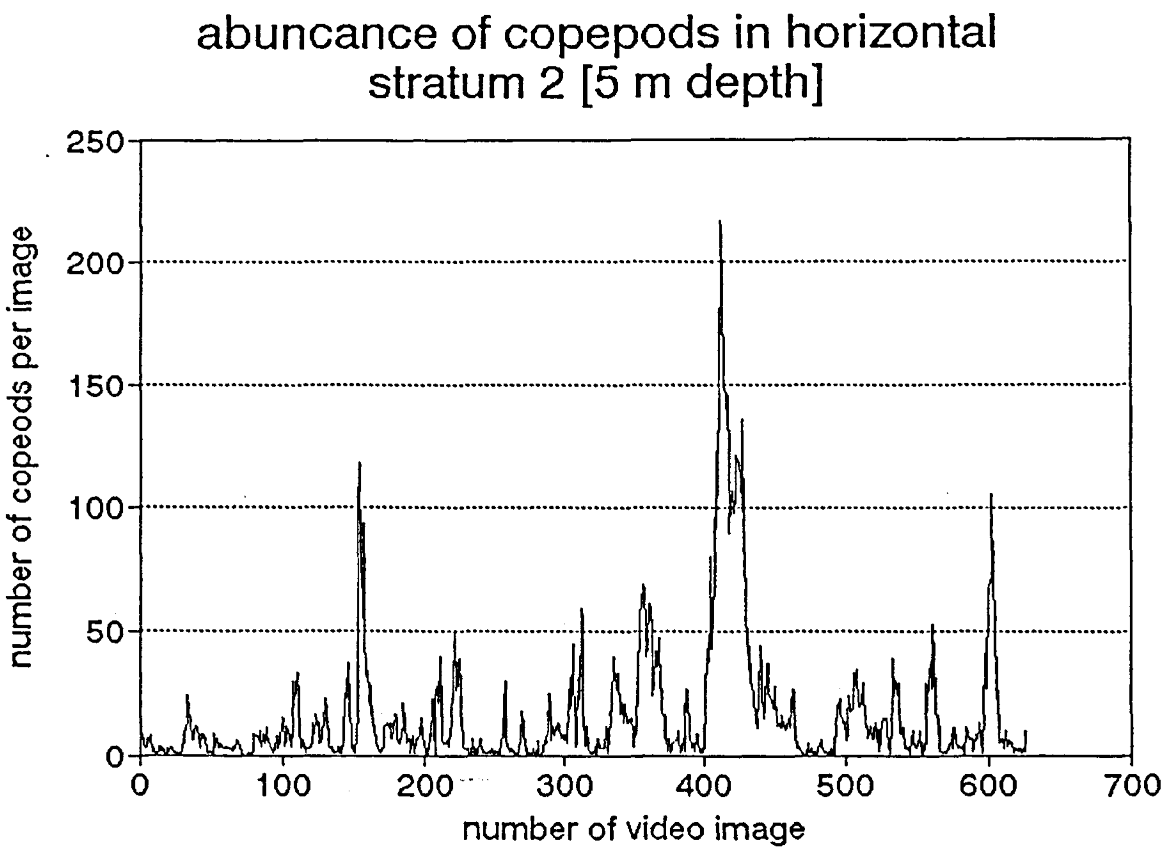
abuncance of copepods in horizontal stratum 2 [5 m depth]
number of copeods per image
0
50
100
150
200
250
0
100
200
300
400
500
600
700
number of video image

fig. 8

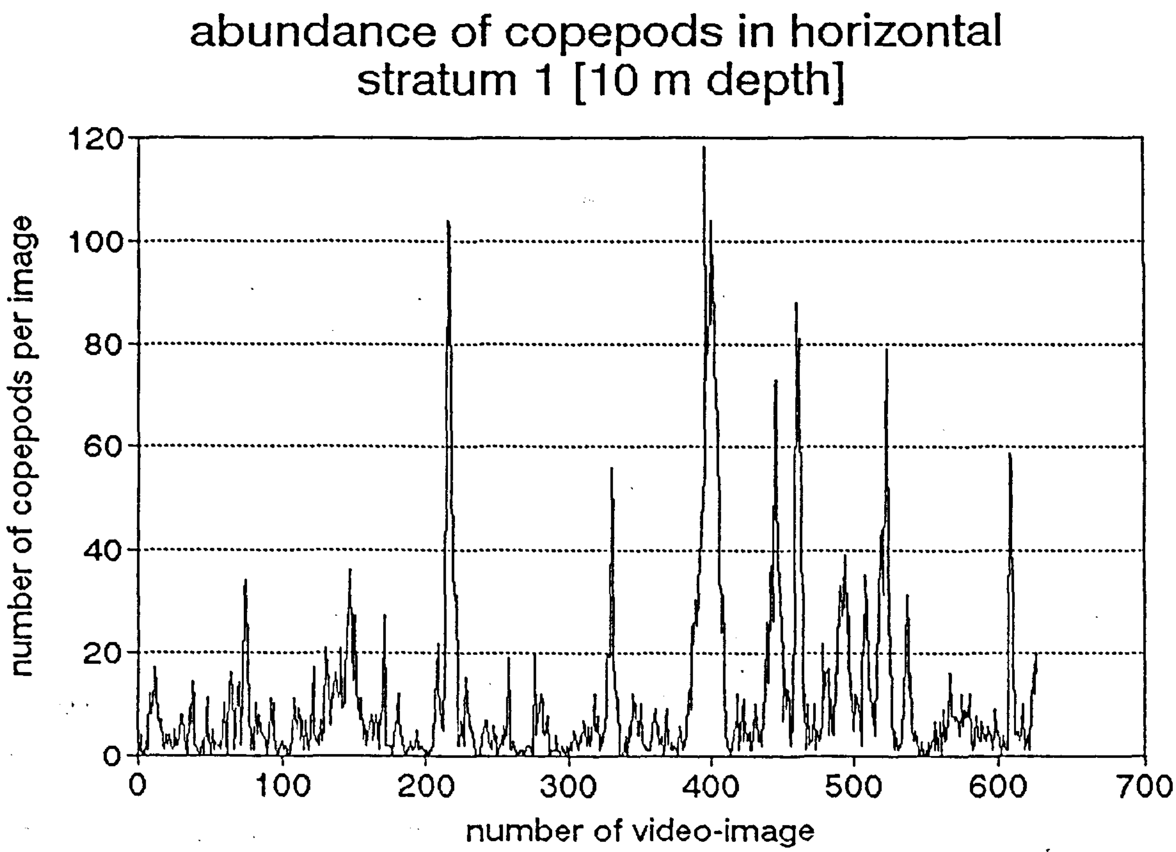
abundance of copepods in horizontal stratum 1 [10 m depth]
number of copepods per image
0
20
40
60
80
100
120
0
100
200
300
400
500
600
700
number of video-image

fig. 9

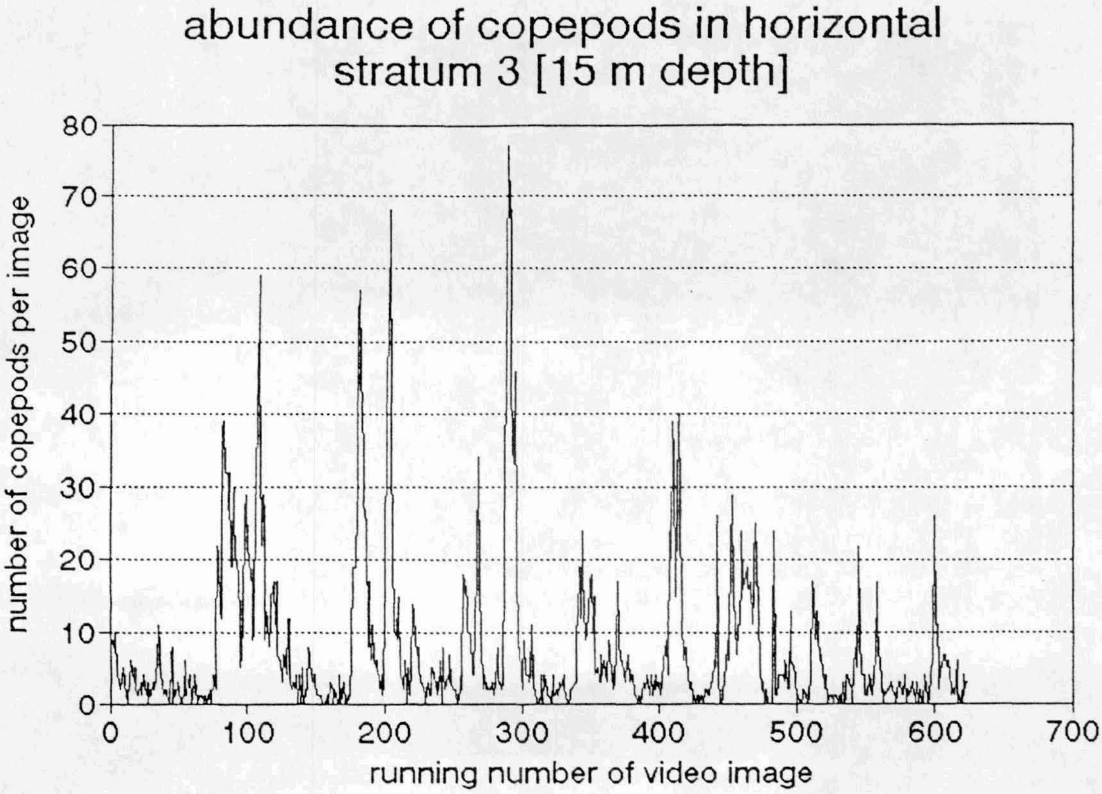

fig. 10

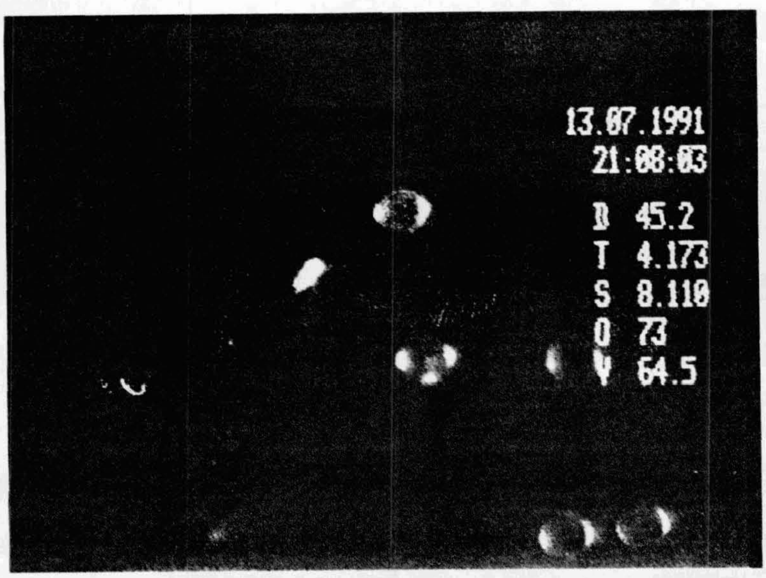

fig. 11: video printout of sprat eggs; environmental data inserted (D = depth, T = temperature, S = salinity, O = oxygen-saturation, V = internal flow velocity [not valid])

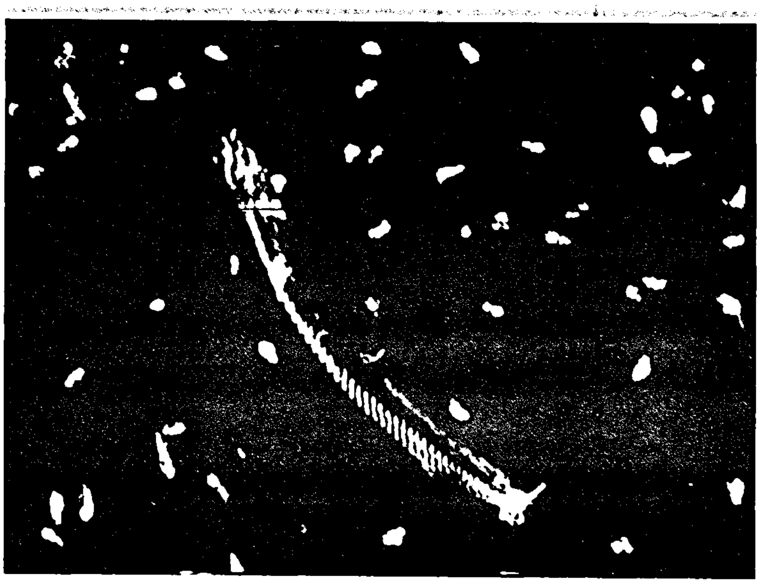

fig. 11 continued; sprat larvae within copepod patch

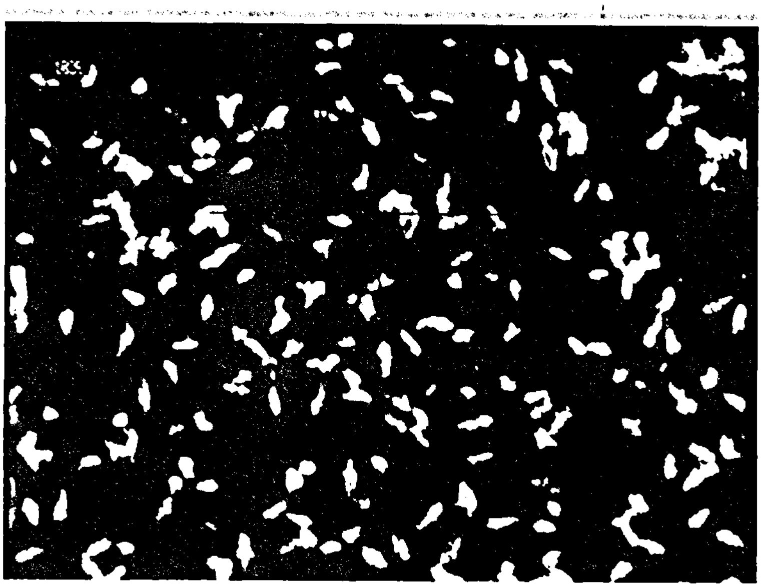

fig. 11 continued; copepod patch