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Video-monitoring of benthic communities in the area off the coast of Kühlungsborn (Mecklenburg Bight) as a means for surveying spatial and temporal changes - advantages and restrictions of a method

Abstract

The area off the coast of Kühlungsborn (Mecklenburg-Vorpommern, Germany) has been subject to intense benthos studies from the beginning of the sixties, mainly by bottom grab, dredging and SCUBA divers.

In 1988, a major oxygen sufficiency had caused a complete breakdown of the benthic communities below a depth of 13 meter. This paper reports on the degree of re-establishment of communities within the last 6 years. It also considers the question of applicability of video survey in these turbid waters.

By using the research yacht „Aldebaran“, which is specially equipped for video-monitoring, the area was surveyed. Video-transects were recorded perpendicular to the coast-line varying between 2 and 26 m in depth.

A special videocamera, controlled by scientists on board, was towed behind the vessel moving slowly along the transect-line. Navigational positions were recorded every two minutes, vertical profiles of physical/chemical parameters at selected sites.

For the verification of uncertain video-images, benthos samples were collected by scientific divers.

Within a relatively short time, a precise description of the spatial changes within the benthic communities of the various zones could be achieved and statements about the general situation of the area and its temporal changes were possible.

Introduction

Benthic invertebrates play a critical role in trophic relationships by providing a major source of energy to ecologically as well as economically important demersal fishes (e.g. COHEN et al.1982). Their number of species reflected also the degree of the health of the ecosystem in consequence of the high sensitivity to bioaccumulation of contaminants (e.g. THOUZEAU et al. 1991).

Regarding the present discussion on long-term changes in marine ecosystems especially referring to potential climatic changes, it seems essential to ask, whether these changes observed are really due to these climatic changes or within the range of the ecosystem's natural variation in time.

Only continuous routine monitoring efforts will enable us to observe change, nevertheless the significance of such changes will generally be dominated by economical factors (fisheries etc.).

The Baltic Sea has been shifting in its regime of salinity from limnic to brackish water conditions vice versa within the last 12 000 years, the development of its present status evolved in recent historical times (e.g. ARNDT 1964 a).

Besides its geologically very young age, the ecology of the Baltic Sea is mainly dominated by its distinctive gradient in salinity from West to East, decreasing from 28 to 4 PSU in surface water. The only way for salt water to flow into the Baltic Sea is through the Kattegat. Euryhaline marine species are found in the West only, whereas the East is dominated by genuine brackish water species and even euryhaline freshwater species.

As a result of the freshwater inflow through rivers, a stratification of heavier salty water in the depth and diluted brackish water in the surface occurs, restricting the oxygen exchange between these two layers. The bathymetric position of the halocline in the central basins of the Baltic Sea oscillates between approx. 90 and 70 m (e.g. von OERTZEN & SCHULZ 1973, GERLACH 1994), depending on the salinity of bottom water. However, the only way for oxygen to be enriched in the near bottom water is by major saltwater inflow. Since certain weather conditions are required for these events, which have not occurred during the last sixteen years till 1993, salinity in the bottom water has been decreased steadily since 1978 (MATTHÄUS 1996).

Whereas no significant salt water inflow into the Baltic Proper east of the Darss Sill took place between 1977 and 1993, the shallow Mecklenburg Bay is characterized by saisonal changing conditions. During spring till late summer a strong stratification is established with low salinities (8 - 10 PSU) and high temperatures (10 - 17 °C) in the surface layer and higher salinities (14 - 18 PSU) and low temperatures (3 - 5 °C) near the bottom (e.g. ARNDT & HEIDECKE 1973). Stormy weather conditions during autumn leads to a total mixing of the water masses with homohaline and homothermal conditions as the result. Periods of bottom water oxygen depletion have never been observed in the open areas of the Mecklenburg Bight. An unique situation occurred in the so-called German Belt Sea (i.e. Mecklenburg Bight plus Kiel Bight) in 1988, when approximately 30% of the bottom surface of the Kattegat were affected by hypoxia (< 2 ml oxygen / l) for a period of more than two months (HELCOM 1994, GERLACH 1994). This oxygen-deficient salt-water (20 - 24 PSU) intruded into the German Belt Sea in September 1988, destroying zoobenthos below 13 m of depth (BÖTTCHER 1990, PRENA 1994).

During the 1960's wide-ranging studies concerning benthic communities were performed along the Mecklenburg coast (ARNDT 1964 a, SCHULZ 1969a, SCHULZ 1969b, von OERTZEN & SCHLUNGBAUM 1972, von OERTZEN & SCHULZ 1973). The area off Kühlungsborn was of special interest on account of its distinct location under periodic influence of Kattegat water. Furnished with a significant amount of large stones in the shallow waters off the coastline the area offers a habitat slightly different from the typical Mecklenburg coastal waters. The Mecklenburg Bay has, in the past, been studied intensively (KÖHN 1989, AL-HISNI 1989). However, since 1988 only few unpublished data have been conducted (VOIGT 1991, THIELE 1991). The objectives of this study were to get an information of the ecological situation in the southern part of the Mecklenburg Bay few years after the breakdown of the fauna 1988 as well as an answer of the question if it is possible to improve the knowlege of an ecological situation by the combination of video technique with traditional sampling methods.

Material and methods

The study was conducted in August 1994 at the Baltic Coast in Mecklenburg-Vorpommern in the area (fig. 1) locally known as „Bukspitze" (approx. 54°11' N, 11° 46' E) on board the research yacht „Aldebaran".

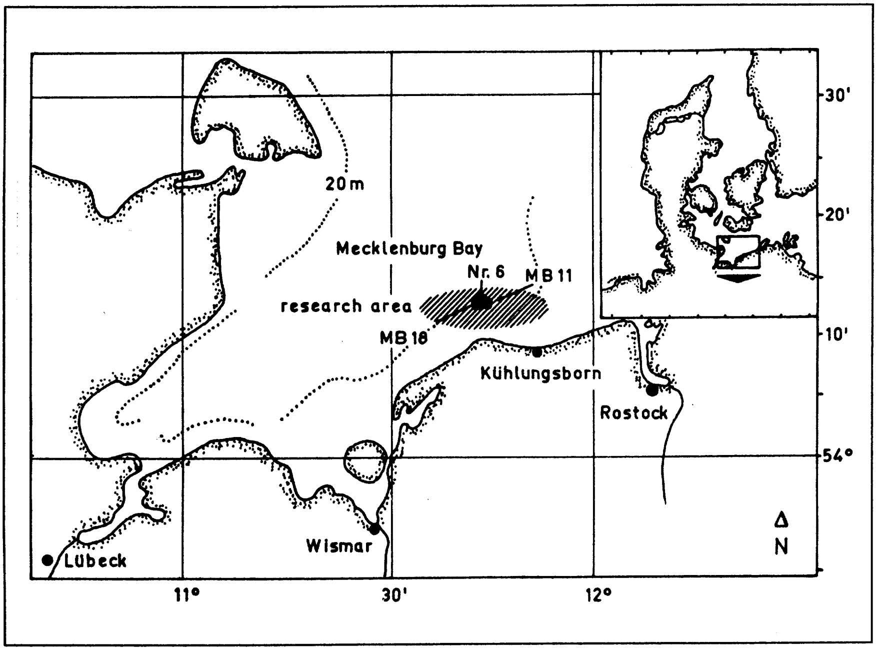

Fig. 1 Study area within the Mecklenburg Bight (Mecklenburg-Vorpommern, Germany), MB 11 and MB 18 being sampling sites from 1986 surveys

The system used was basically a towed sledge (MACHAN & FEDRA 1975, HOLME & BARRETT 1977), on which was mounted a 45° forward-angled video-camera and two respectively mounted lights (100 W). The camera, installed in a aluminium case, was a SONY CCD Hi8-Camcorder with a resolution of 470.000 pixel, autofocus and zooming facilities. Easy handling was assured by the light weight of sledge and camera (20 kg), snap clamps and socket-switch connection for video and electrical cables.

Even though the eutrophication of the Baltic coastal waters is severe, artificial light was not needed throughout the study, on account of the cameras high sensitivity and excellent water conditions.

The distance of the camera to the centre of the observation field was about 1,0 m, giving a picture width of approx. 0,5 m.

During the survey, the actual position of the vessel was determined by differential GPS (Magellan 5000 DX) every two minutes. At the same time depth measurements were recorded from the continuously running echo-sounder. The maintenance of the exact predetermined course often proved to be difficult with the slow towing speed (maximum 1 knot) required for good video pictures.

Simultaneously to the recording, video pictures were observed and annotated for the first time, by two observers. A second tape analysis was carried out on shore later by all participating scientists.

The survey which took place during a 4 day cruise, consisted of 9 transect lines and 5 positions for SCUBA diving ranging from 3 to 26 m depth, according to the sampling positions of preceding studies (KÖHN 1989, AL-HISNI 1989).

In addition to video monitoring, each transect line was examined by means of Van-Veen-grab, bottom dredge and sampling by SCUBA divers. Respectively the grab sampling took place at the end of a viedeo transect, whereas dredge samples were taken in between two video transects.

Routinously vertical profiles of salinity, oxygen, pH and temperature were taken at grab sampling positions, by WTW-probes.

Collected grab and dredge samples were partly fixed in ethanol or formalin (4%) on board, whereas determination of species, biomass and number of individuals was carried out in the laboratory at a later stage.

Results

The benthic community observed by the combination of grab sampling and video survey showed a overall qualitative species identity to 1986 data (KÖHN 1989) between 20 and 28 % by SÖRENSEN index, for corresponding sampling sites (Table 1). Whereas KÖHN (1989) and AL-HISNI (1989) found a total of 59 taxa during 1 year of grab sampling, we could identify 39 taxa, of which 27 were identical to 1986 data, in spite of random sampling covering only one seasonal aspect, disgarding species present during spring and early summer only.

Table 1 Comparison of species found by grab sampling before and after the 1988 breakdown, at corresponding sampling sites in a depth of 19 m

	July 1986 MB 11 (Köhn 1989)	**July 1986 MB 18** (Al Hisni 1989)	**August 1994 Site Nr. 6**
Observed species	**Ind./m^2**	**Ind./m^2**	**Ind./m^2**
Nemertini			130
Priapulida			
Priapulus caudatus			13
Polycheata			
Ampharete finmarchica	13		
Anataides maculata	7	13	195
Antinoella sarsi	60	35	65
Arenicola marina			13
Arcidea jeffreysi	10	8	
Capitella capitata	2		52
Eulalia bilineata		2	
Eteone longa	9		52
Hamothoe imbricata	2		13
Heteromastus filiformis	3	23	
Lagis koreni			39
Laonome kröyeri	2		
Nephtys spp.	68	67	26
Nereis diversicolor			39
Paraonis gracilis	3	67	
Pholoe minuta	69		196
Polydora ciliata	7		13
Polydora quadrilobata	257	58	13
Pygospio elegans	80		
Scoloplos armiger	237	688	300
Spio goniocephala	2		
Terebellides stroemi	3	28	
Trochochaeta multisetosa	2		13
Crustacea			
Corophium crassicomis		5	
Diastylis rathkei	692	238	534
Grastrosaccus spinifer			39
Echinodermata			
Asterias rubens			13
Tunicata			
Styela coriacea			13
Gastropoda			
Hydrobia neglecta	3		
Bivalvia			
Abra alba			91
Arctica islandica	78	123	26
Astarte borealis	177	132	
Astarte elliptica	23		
Cerastoderma lamarcki			26
Corbula gibba		13	
Macoma balthica	883	328	156
Macoma calcarea	30	108	
Mya truncata	3	2	
Mysella bidentata	23	203	
Mytilus edulis	800		

Of these 39 taxa 12 species could be identified by grab sampling as well as video, whereas 23 taxa were only detectable by grab sampling and 4 species exclusively by video.

The uniformity of the ecological situation in the deeper parts below a depth of 20 m was an outstanding impression, because of a relatively high heterogeneity observed in this area during the 1960's. The whole area observed showed a well-oxygenated surface layer of sediments covered by a layer of pre-sediment. This pre-sediment was arranged in form of a 'ripple mark' structure.

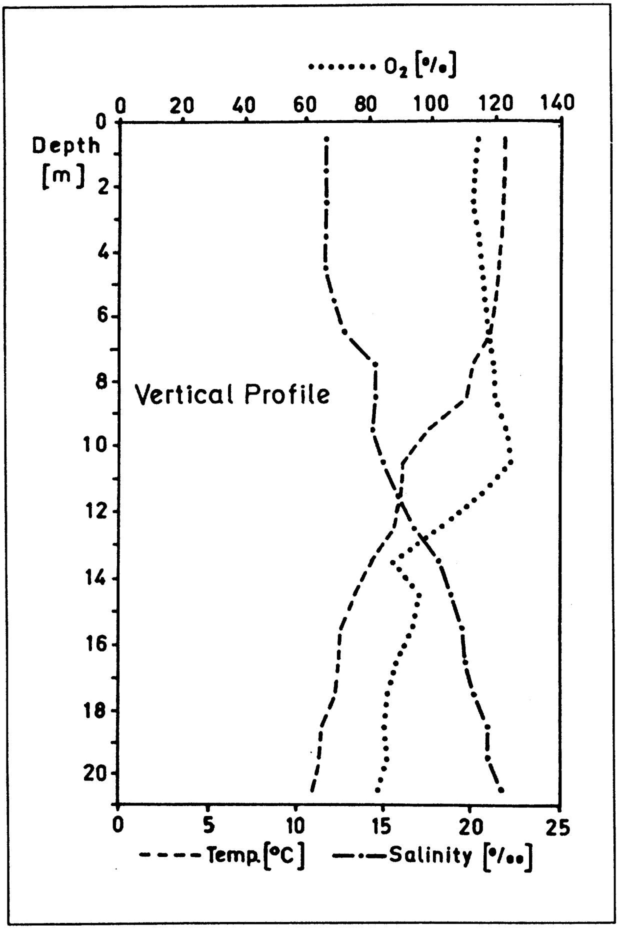

Fig. 2 Vertical profile of temperature, Oxygen and salinity of sampling site Nr. 6

Difficulty was experienced in distinguishing live *Astarte* from dead shells by camera. The percentage of living specimens had to be evaluated by dredging and direct underwater observations by divers. According to the largest size class of live *Astarte* observed, living individuals were not older than 3 - 4 years. A fact, corresponding to observations by VOIGT (1991) stating large areas along Mecklenburg coast with dead mussels during a spring 1990 survey.

A remarkable fact was the complete disappearance of the mussel *Mytilus edulis* from the area below a depth of approximately 14 m. Whereas *M. edulis* in 1986 was one of the dominating species down to 18 m in depth (KÖHN 1989) its bathymetric distribution in 1994 came to a sudden end at a depth of 14 m. Video transects running perpendicular to the shore line showed that only lumps of free floating mussels were to be found below this depth. Hence, there seems to be a factor (respectively a combination of various factors) hindering the mussel's re-establishment in the area after the 1988 breakdown.

Regarding physical/chemical parameters a vertical stratification in the water body, which was homogeneous throughout the area, became apparent (fig. 2). Between 12 and 13 m depth a thermocline/halocline is clearly visible, with temperature dropping almost 2° C and salinity rising for approximately 1,5 PSU.

In between *M. edulis* at a depth between 14 and 10 m, patches of the sulfur bacteria *Beggiatoa* became clearly visible as well as traces of bioturbation activities of unknown origin. The core area of the *Mytilus* banks were densely inhabited by *Asterias rubens*, feeding on the mussels. On account of salinity limits (ARNDT 1964 b) *A. rubens* was not found above 11 - 13 m, whereas single specimens were observed down to a depth of 26 m.

Precise data could be achieved on the distribution of *Arenicola marina* by means of video, whereas grab samples included only a few pieces of living animals, on account of *A. marina*'s way of life in the sediment.

The emphasis of *A. marina*'s distribution is in the sublitoral zone within the range of 7 to 11 m of depth. Dense populations of *A. marina* together with *Mya arenaria* could be observed in the area in between the mussel banks and the Zostera region (*Zostera marina).* With increasing depth, the population density of *A. marina* decreased in almost the same amount as the population density of *M. edulis* grew (fig. 3). At the bathymetric end of *M. edulis*' distribution *A. marina* re-increases in population density, finally coming to an end of its distribution at a depth of 19 m.

The brittle star *Ophiura albida* had been reported in vast quantities in some years during the 1960's, with data on its existence in the research area (ARNDT 1964 a). Eventhough AL-HISNI (1989) describes frequent observations of *O. albida* in grab samples, no single specimen could be found during 1994 video survey, though this species should have been clearly visible by video camera.

Besides *O. albida* another marine species used to be common for the area, the Anthozoa *Metridium senile* (ARNDT 1964 a). Whereas KÖHN (1989) is lacking both of these species, AL-HISNI (1989) also describes *M. senile* for sampling site MB 18. At the present this species is still existent in the area off Kühlngsborn, *M. senile*

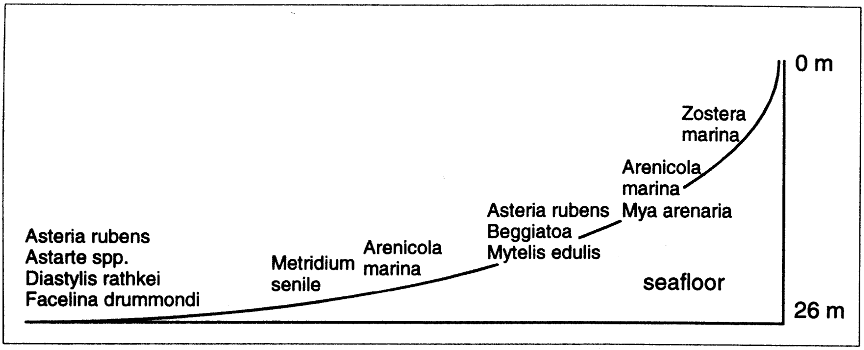

Fig. 3 Spatial distribution of epibenthic fauna (and flora) as it could be observed by video transect, species which were only detectable by grab sampling are missing. *Asterias rubens, Metridium senile, Facelina drummondi* and *Arenicola marina* were missed in the grab samples respectively

could clearly be observed on the video screen, yet ist appearance was very sporadic and its distribution limited to the presence of larger stones.

A species clearly underestimated or not described in previous studies, was the nudibranch *Facelina drummondi*. Though the nudibranch had been noted in diver surveys at a depth of 20 m (ARNDT 1964 a) and 15 m (GOSSELCK 1992), respectively, it was missing in all grab sampling surveys from the survey area (KÖHN 1989, AL-HISNI 1989, RINGELTAUBE 1989). Nevertheless, the mollusc was observed with the video camera in relatively dense populations averaging up to 10 ind./m in a depth of 26 m.

Discussion

The major survey effort was to test the combination of methods in an area well known. By a combination of methods giving proper alliance between expenditure, time, cost and information it was possible to judge the longterm faunal trend within a relatively short time of field work and allow general statements on the situation of the benthic fauna and its habitat conditions.

From the data of this previous survey it seemed that the benthic community below 13 m of depth which had re-established, was almost the same as it had been before the 1988 breakdown, though the spatial distribution of single species has altered remarkably.

In comparison to the situation during the 1960's the macroscopic view seems to be changed in a direction caused by eutrophication. The whole area up to 20 m in the depth is covered by a thin layer of pre-sediment (i.e. detritus). Macroalgae like *Laminaria spec.* disappeared below the pycnocline, we observed by video only few specimens in a depth of 15 m. Similar changes in macroalgae distribution since the

1960's found BREUER & SCHRAMM (1989) in Kiel Bight and PRENA (1990) in Wismar-Bay. We suppose that the disappearance of the tube-living sabellid *Euchone papillosa*, common in the soft bottom area below a depth of 20 m in the past (ARNDT 1964 a, 1967), is caused by the pre-sediment layer.

The fact that *Ophiura albida* has vanished completely corresponds with observations in the 1960's, where *O. albida* were present in some years and missing in other ones. *O. albida* is a relatively stenohaline marine species with a generative borderline in the Kattegat area. The presence of this species as unfertile specimens in the Mecklenburg Bight (vegetative borderline) is up to the larval transport through Great Belt and Fehmarn Belt by saltrich water during the reproduction time (ARNDT 1964 a).

As far as species are concerned, which are clearly determinable by camera, data from KÖHN (1989) on *Mytilus edulis* proved the decline of vertical distribution of this species of about 5 m. *Arenicola marina* in contrast was not present, neither in the study by KÖHN (1989) nor by AL-HISNI (1989), a fact that is most likely due to sampling method exclusively. In the case of this important species in terms of biomass, the additional use of video proved substantial.

Camera and video transects have been used to estimate the abundance of megabenthic epifauna in various studies (MACHAN & FEDRA 1975, FRANKLIN et al. 1980, PATTERSON 1984, JAMISON et al. 1984, MacDONALD et al. 1989, THOUZEAU et al. 1991, RUMOHR 1993) and have come to be an established method.

The use of video images not only enlarges knowledge on the benthic community achieved by grab sampling, furthermore it represents a time saving and inexpensive method for routine monitoring, required for ecological management which can not afford intensive benthic studies but nevertheless has to judge ecological conditions for further actions and there fore needs quick access to data (RUMOHR 1993).

Especially regarding habitat destruction by dredge and grab sampling in systems already under continuous ecological stress, destructive techniques should be reduced to a minimal level.

If grab sampling is used as the only method, it will surely give an uncomplete impression on the situation (which is also true for video of course) of the benthic communities not taking patchiness of habitats sufficiently into account.

Grab sampling in the Bornholm Basin for example (HAGMEIER 1930, DEMEL & MANKOWSKI 1951, DEMEL & MULICKI 1954, RUMOHR 1987) proved the existence of living bivalves below a depth of 80 m during the first half of this century. Whereas with sediment cores from 88 and 92 m depth, JONSSON et al. (1990) found an undisturbed sedimentation in at least 200 sediment layers implying the absence of any bioturbation in the area, for a couple of centuries. These apparently contradicting results have led to speculations on a patchy habitat structure which might have existed in the Bornholm Basin, leaving single depressions with oxygen deficient water bodies uninhabited (GERLACH 1994).

Video recording of the habitat structure certainly gives supporting data, necessary for ecological interpretation of grab samples. Furthermore grab sampling may be reduced to the lowest limit necessary, if preceding video scanning checks the existence of variability of habitat structures.

Video survey in contrast only considers epibenthic fauna with a minimum size, depending an camera resolution and turbidity, usually ranging from 10 to 40 mm (FRANKLIN et al. 1980, THOUZEAU et al. 1991). But since epibenthic organisms in most coastal systems represent an important part of the macrofauna video technology is one way to increase data acquisition over limited periods.

Recent advances in camera and recording technique allow recording of a continuous stream of images with resolution and colour saturation sufficient to identify fauna, determine fine-scale substrate characteristics (MALATESTA et al. 1992) and assure the use of modern image processing for analysis.

A common problem of grab sampling is the escape of mobile species, since bottom-samplers not only trigger an avoidance response when approaching the seafloor (THOUZEAU et al. 1991), but also wash away lighter species by its pressure head (RUMOHR 1993), coming down. This might be the reason, why *Facelina drummondi* was never observed in previous studies, entirely done by grab sampling.

Storage of physical/chemical data, navigational position, depth etc. on the same video tape for subsequent extraction to computer processing, permits easy handling of the equipment on board, whereas reproducible data inspection later is guaranteed.

Various studies have evaluated methods for quantifying video transect images, statistical treatment of data and development of standards (FRANKLIN et al. 1984, McCORMICK & CHOAT 1987, THOUZEAU et al. 1991, AUSTER et al. 1992, MALATESTA et al. 1992). Further development in video technique and digital image processing will increase the advantages of this method for monitoring use.

Conclusions

Modern ecological sampling often requires a non-destructive sampling technique which provides quantitative data on community structure and demographic parameters within defined habitats (WHORFF et al. 1992). Furthermore environmental impact studies and routine monitoring efforts reqire time-saving and inexpensive methods leading to a maximum of information at a minimum expenditure.

The advantage of using video survey certainly is the creation of a permanent record that can be reviewed multiple times to complete enumeration of all individuals, take individual observers biases into account (AUSTER et al. 1992) and be discussed with external experts. Nevertheless, major disadvantage is the difficulty in identifying similar and small species and the neglect of non epibenthic species.

However, transformed data appearing in tables and charts are often less easily compared than a visual presentation of the same data (WHORFF et al. 1992, RUMOHR 1993). Especially since the need for managers and politicians to really understand ecological subjects in importunate, visual presentation on changes might help support long term scientific efforts.

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