

NOTE

Increase in macrozoobenthos above the halocline in Kiel Bay comparing the 1960s with the 1980s

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ABSTRACT: The macrobenthos of sandy sediments in the 9 to 13 m water depth area of Kiel Bay was investigated. Data from 1961 to 1965 were compared with data from 1982/83. Biomass of total macrobenthos was significantly higher in 1982/83 (14.6 g ash-free dry weight m^{-2}) than in 1961 to 1965 (4.7 g AFDW m^{-2}). This increase is mainly caused by mollusc species. Eutrophication, changes in predation pressure and changes in physical disturbance are discussed as possible reasons.

Introduction. In the Baltic Sea and in adjacent areas several attempts have been made to reinvestigate the macrobenthos of areas sampled in the 1920s (e.g. Rosenberg & Möller 1979, Cederwall & Elmgren 1980, Persson 1981) and to explain the generally found increase in macrobenthos above the halocline. The intention of this paper is to identify and to discuss the distinct increase in macrobenthos in Kiel Bay above the halocline during the last 20 yr.

Methods. I compared data from 2 studies carried out in 1961 to 1965 (Kühlmorgan-Hille 1965) and in 1982/83 (Brey 1984). Four stations of the first study (sampled at least 7 times from 1961 to 1965) and 16 stations of the second study (sampled 1 time) are situated in the same waterdepth range (9 to 13 m, Fig. 1) and show similar sediments ranging from medium to fine sand.

In both studies a 0.1 m^2 VanVeen grab, a sieve with 1 mm mesh size and 4 % formalin for storage were used. Kühlmorgan-Hille (1965) collected 2 samples at each station and date, in 1982/83 I collected at least 3 samples at every station. Both data sets compared here depend on a total of 58 0.1 m^2 samples.

For comparison I converted the wet weight biomass data from 1961 to 1965 into ash-free dry weight (AFDW) following conversion factors reviewed by Rumohr et al. (unpubl.). The mean conversion factor (WW/AFDW) for Mollusca is 13.9, for Polychaeta 7.2 and for Crustacea 6.0. Other taxa have been neglected.

Kühlmorgan-Hille (1965) did not determine biomass on the species level, so I compared only biomass of Mollusca, Polychaeta and total macrozoobenthos and abundance of medium- and large-sized, numerically important species which are not too sensitive to the sieving procedure. Biomass of Crustacea was in general too low for comparison.

For statistical purposes I used a median-quartile-test created by Bauer (quoted from Sachs 1978). Average relative frequencies were calculated by means of arc sin transformation.

Results. The species composition of the benthic fauna was nearly the same in both periods.

The total macrobenthic biomass was significantly higher in 1982/83 (14.6 g AFDW m^{-2}) than in 1961 to 1965 (4.7 g AFDW m^{-2}) (Table 1). This was due to a large increase in the biomass of molluscs (1961 to 1965: 2.1 g AFDW m^{-2} , 1982/83: 12.8 g AFDW m^{-2}). The biomass of polychaetes showed no significant difference between the 2 periods (1961 to 1965: 1.5 g AFDW m^{-2} , 1982/83: 1.6 g AFDW m^{-2}). Four mollusc species showed a significant increase in average abundance (Table 2). Two of these species, *Macoma baltica* (L.) and *Mya arenaria* (L.), contributed an important part to total mollusc biomass in 1982/83 (on average 48 and 10 % respectively).

The 2 burying polychaetes *Nephtys* spp. and *Scoloplos armiger* (O. F. Müller) showed no changes in abundance.

Discussion. The difference in biomass of molluscs at sandy substrata in the 9 to 13 m waterdepth range of Kiel Bay, comparing sampling periods about 20 yr apart, may be caused either by different methods and different stations sampled during the 2 investigations, or by long-term fluctuations or long-term trends in macrozoobenthic abundance and biomass.

The grabs used during the 2 investigations seem to

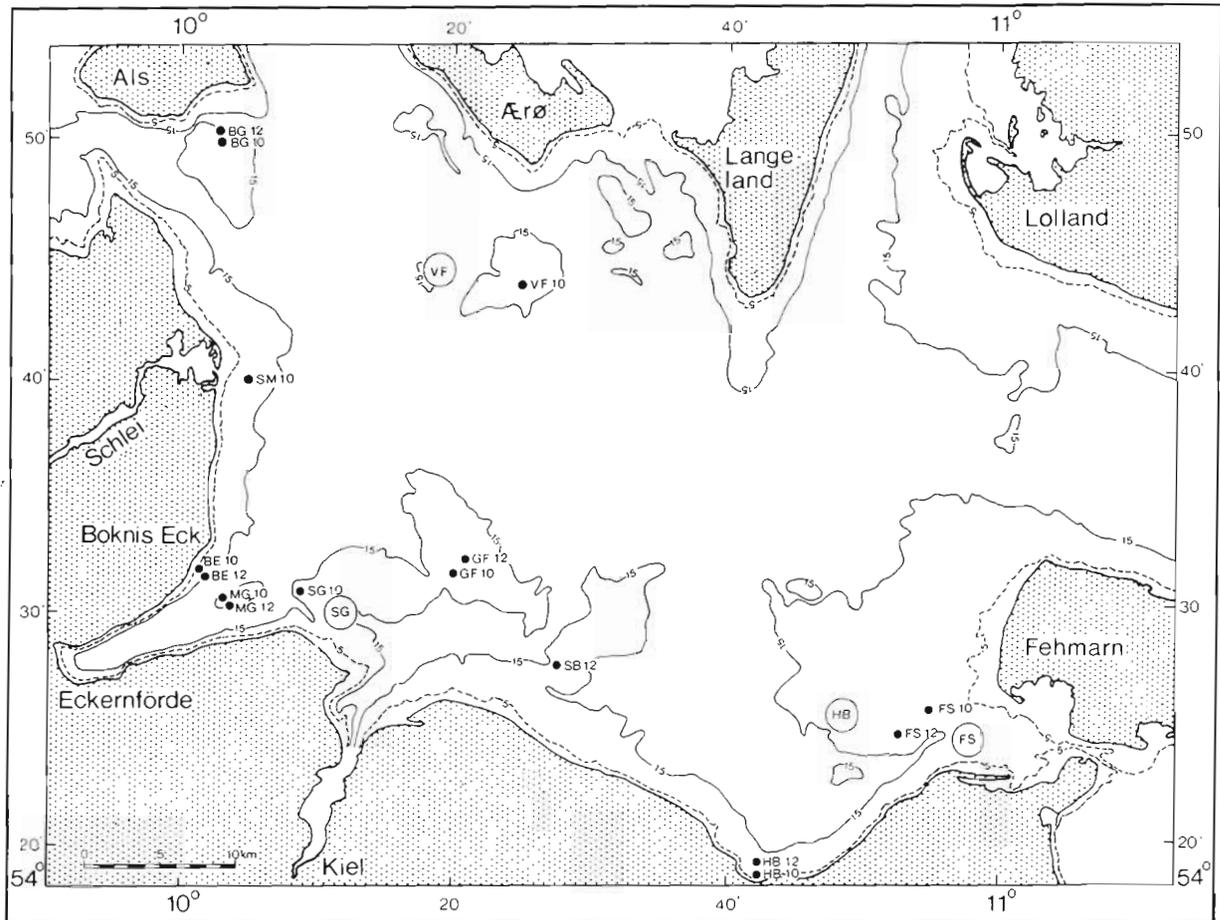


Fig. 1. Location of stations in Kiel Bay. Circles: stations sampled by Kühlmorgen-Hille in 1961 to 1965. Dots: stations sampled by Brey in 1982/83

Table 1. Average biomass (g AFDW m^{-2}) of Kiel Bay macrozoobenthos from sandy sediments in 9 to 13 m water depth in 1961 to 1965 ($n = 29$) and in 1982/1983 ($n = 16$)

| Taxon | 1961–1965 | | | Significant difference at 5% level | 1982/1983 | | |
|------------|-----------|--------------------------------------|-----|------------------------------------|-----------|--------------------------------------|------|
| | Median | 95% confidence limits Lower Upper | | | Median | 95% confidence limits Lower Upper | |
| Mollusca | 2.1 | 1.2 | 5.3 | Yes | 12.8 | 8.9 | 17.8 |
| Polychaeta | 1.5 | 1.1 | 2.3 | No | 1.6 | 0.8 | 2.3 |
| Total | 4.7 | 2.6 | 9.2 | Yes | 14.6 | 11.5 | 19.6 |

differ little. Kühlmorgen-Hille (pers. comm.) used a $0.1 m^2$ VanVeen grab loaded with lead weights. In 1982/83 I used a $0.1 m^2$ VanVeen (weight: 60 kg) grab with windows at the upper side covered with 0.5 mm metal gauze. During both investigations a 1 mm sieve was used. Because only biomass data of main taxonomic groups and abundance data of medium- and large-sized species are compared here, neither differences in the strength of the shock wave in front of the

lowered grab nor differences in sieving efficiency, which both affect only small specimens seriously (Ankar 1976, Ankar 1977), are sufficient explanations for the observed large differences. The penetration depth of both grabs, which is the most important parameter affecting biomass figures, is assumed to be fairly similar, because there are no differences in the abundance of the burying polychaetes *Nephtys* spp. and *Scoloplos armiger*.

Table 2. Average abundance (no. m⁻²) of 6 important macrobenthic species in Kiel Bay from sandy sediments in 9 to 13 m waterdepth in 1961 to 1965 (n = 29) and in 1982/1983 (n = 16)

| Taxon | 1961–1965 | | | Significant difference at the 5% level | 1982/1983 | | |
|------------------------------------|-----------|--------------------------------------|-----|--|-----------|--------------------------------------|------|
| | Median | 95% confidence limits Lower Upper | | | Median | 95% confidence limits Lower Upper | |
| <i>Corbula gibba</i> | 15 | 5 | 25 | Yes | 154 | 57 | 1042 |
| <i>Macoma baltica</i> | 30 | 0 | 75 | Yes | 988 | 541 | 1681 |
| <i>Mya arenaria</i> ¹ | 0 | 0 | 20 | Yes | 67 | 3 | 798 |
| <i>Mytilus edulis</i> ² | 0 | 0 | 0 | Yes | 49 | 3 | 579 |
| <i>Nephtys</i> spp. | 45 | 35 | 55 | No | 59 | 40 | 64 |
| <i>Scoloplos armiger</i> | 165 | 45 | 250 | No | 143 | 30 | 217 |

¹ Found only 9 times during 1961–65
² Found only 6 times during 1961–65

The sites of the stations sampled in 1961 to 1965 and in 1982/83 are different (see Fig. 1), but I consider it unnecessary to resample exactly the same positions 20 yr later, because of the patchy distribution of shallow water macrobenthos and because of the change of this patchy pattern with time. The total number of independent samples (from the same depth- and sediment-stratum) is probably much more important. The data sets compared here both include a total of 58 0.1 m² samples, which should be sufficient for a comparison at the level of main taxa.

The distribution of sampling dates within the year differs only little between the 2 studies. Both in 1961 to 1965 and in 1982/83 about half the sampling dates were during the period July to September, which is the period of highest benthic production and biomass in the shallow water area of Kiel Bay (Brey 1984).

Thus it seems that methodical deviations are not sufficient to explain the large differences in shallow water mollusc biomass between the early 1960s (2.1 g AFDW m⁻²) and 1982/83 (12.8 g AFDW m⁻²).

It is impossible to recognize in which species this increase occurred, because Kühlmorgan-Hille did not determine the biomass of single species. In general an increase in the biomass of molluscs could be due to (1) an increase in available food or to (2) a variation in a main physically limiting factor or to (3) a decrease in predation pressure.

(1) Increase in food supply. Although no long term data on primary production in Kiel Bay exists, an increase in both benthic and pelagic primary production due to the large input of nutrients from land every year (Larsson et al. 1985) probably occurred during the last decades. The hypothesis of Cederwall & Elmgren (1980) that eutrophication is the reason for a long term increase in macrobenthic biomass of the Baltic Sea could also apply to the shallow water area of Kiel Bay.

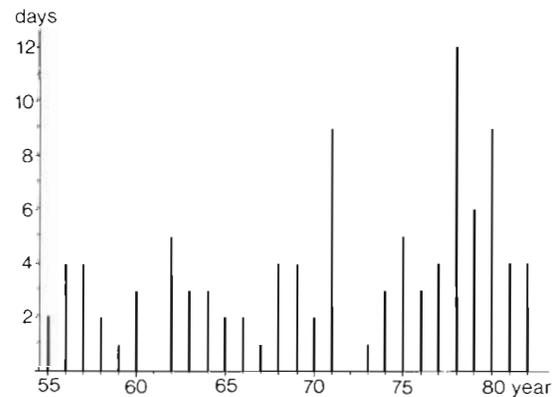


Fig. 2. Number of stormy summer days with more than 25 kn windspeed in the Kiel Bay area 1955 to 1982. Data from lightvessel 'Fehmarnbelt'. Source: Deutscher Wetterdienst, Seewetteramt

(2) Variation in a physically limiting factor. Physical disturbance is presumed to be an important controlling factor of distribution and abundance of shallow water benthic animals (McCall 1978, Yingst & Rhoads 1978). In Kiel Bay strong water turbulence due to storms causes disturbance and erosion of the sediments down to 18 m (Seibold et al. 1971). A summer without strong gales may allow high survival of recruits in long-lived species such as *Macoma baltica* and *Mya arenaria*. Subsequent years with calm summer weather should be reflected in a noticeable long-term increase in the biomass of long-lived species. Fig. 2 shows the number of summer storms (Apr through Sep) with windspeed above 25 kn between 1955 and 1966, recorded by the light-vessel 'Fehmarnbelt'. There were clearly more summer storms during the late 1970s and early 1980s than during the late 1950s and early 1960s. Therefore a better recruitment due to calm summer weather cannot be the reason for the higher biomass found in 1982/83.

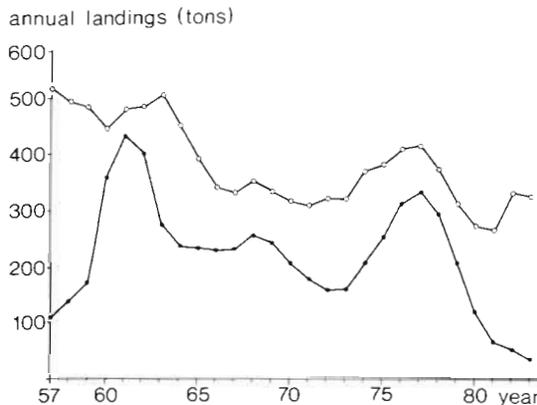


Fig. 3. Annual landings of flounder (○) and plaice (●) by German fishery in Kiel Bay 1957 to 1983. Running mean over 3 yr. Source: Annual reports on German fisheries (1957 to 1971), Die Kleine Hochsee- und Küstenfischerei (1972–1983)

(3) Decrease in predation pressure. Persson (1981) supposes that the increase in macrozoobenthos in the Baltic Sea between the 1920s and 1950s is due to changes in the exploitation of flatfish stocks in the 1920s and early 1930s. The main predators in shallow water soft bottom communities are *Crangon* spp., gobies, young plaice and flounder (e.g. de Vlas 1979, Evans 1983). No long term data are available about *Crangon* spp. and gobies. Changes in flatfish stock size should be reflected in changes in the landings of fisheries in Kiel Bay. Fig. 3 shows that landings of flounder decreased by about 40 % since the late 1950s. Landings of plaice were much higher in the early 1960s than in the early 1980s. These data indicate that the increase in macrobenthic biomass in the shallow water area of Kiel Bay could be related to a decrease in the size of plaice and flounder stocks.

The data presented here are not conclusive as to the real reason for the increase in macrobenthic biomass in the shallow water area of Kiel Bay from the 1960s to the 1980s. The data available indicate changes in predation pressure to be the most likely reason, but it is rather difficult to separate effects of diffuse eutrophication on shallow water macrobenthos from effects caused by natural fluctuations (*sensu* Rosenberg & Möller 1979), e.g. changes in predation pressure or changes in physically limiting factors.

Acknowledgements. I thank the late G. Kühlmorgen-Hille, who provided me with some unpublished data, and M. Stengel for computing the meteorological data.

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