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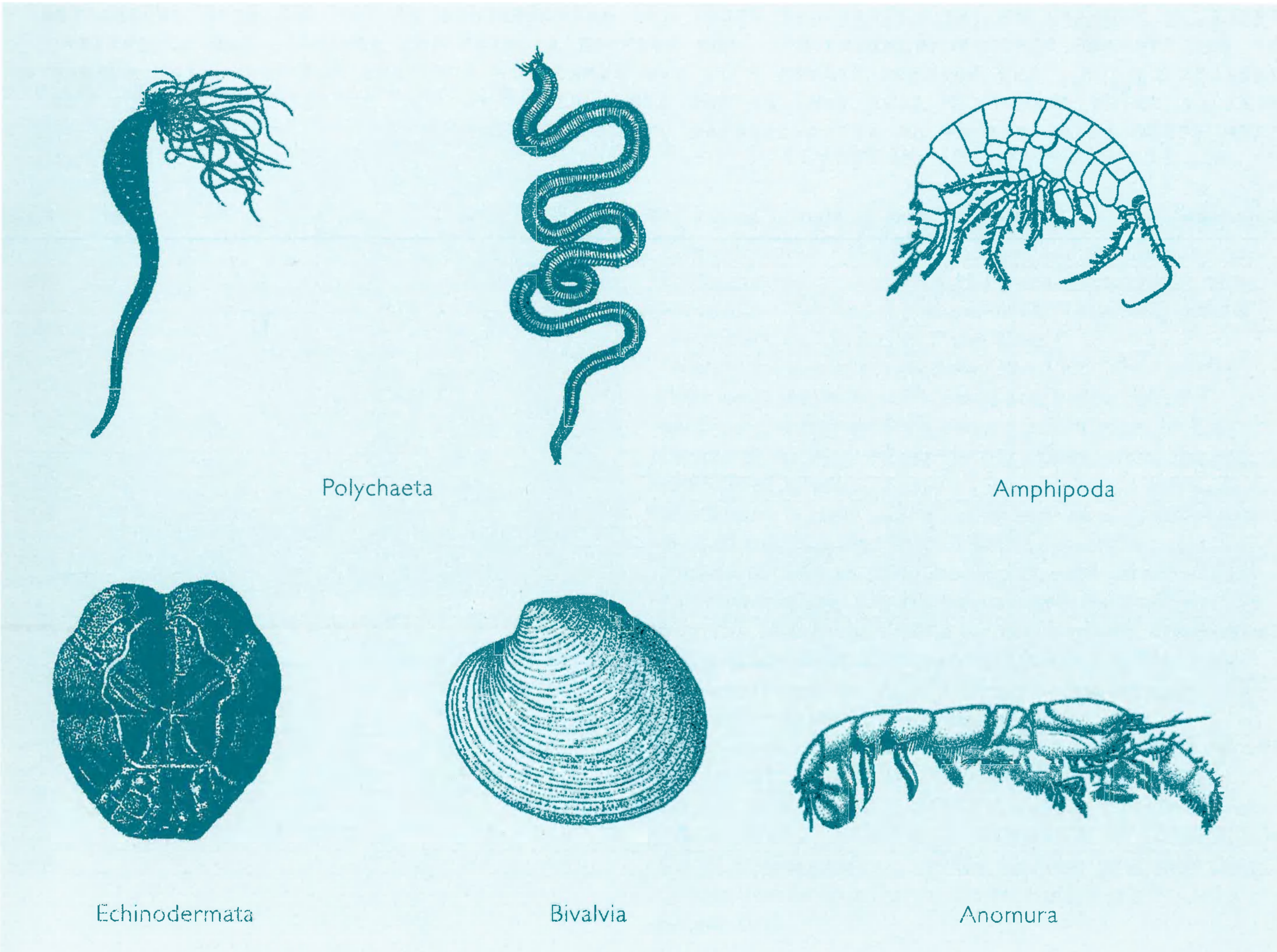
4. MACROFAUNA BIODIVERSITY PATTERNS OF THE BELGIAN COASTAL WATERS

4.1. DEFINITION

Macrobenthos is the infauna retained on a 1mm sieve. The most important organisms are bivalves, polychaete worms and amphipods, next to infaunal echinoderms, decapods, gastropods and oligochaetes that are less representative organisms (Plate 2). Burying larger crustaceans like *Callianassa* and some bivalve species like *Ensis* are common in coastal waters but often these animals bury too deep into the sediments for efficient sampling.

PLATE 2. MACROFAUNA TAXA



4.2. Results

Table 2 summarises the macrobenthic literature of the BCS. Like for the meiofauna studies, a number of results apply to the BCS but were based on samples collected on the BCS and/or in the Dutch or French coastal waters. A large methodological discrepancy exists between the different macrobenthos studies. The mesh size of the sieve has changed and concomitantly the moment of sample fixation. The first studies mention the presence of a 250µm sieve under the 0.87mm sieve that allowed to sample smaller size fractions. Only when the published data allowed distinguishing between both size fractions the larger fraction was used in the analysis. It needs mentioning that the results obtained with both methodologies differ substantially and this hampers comparing the data.

The intensity of the macrobenthos research differs strongly between the nine zones. Similar to the meiofauna, the coastal area and the Flemish Banks were far better surveyed than the other regions (Fig. 7). Especially for the gullies between the sandbanks and the most remote open sea area (zone 9) few studies exist.

The recent studies have simultaneously sampled both the slopes of the banks and the gullies between the banks. Zone 6 and 8 have thus been sampled but the data have been presented as data for zone 5 and 7 since it was difficult to track what samples were taken in what stratum. Yet, most samples were collected on the slope of the banks and therefore we consider all samples as slope samples.

Figure 8 represents the average recorded densities for each zone. While the density data for the meiobenthos did not show a trend, the averaged macrofauna densities tend to decrease towards the open sea. The existing methodological differences caution for interpreting these average densities.

The early study of Govaere (1978) covers the whole BCS and contradicts this picture (Table 2). This author describes an increasing average density, average number of species and species diversity (H') towards the open sea. The recent study of Coenjaerts (1997) sampled only four of the nine areas but his results suggest a contrasting pattern: a decreasing density and no trend in inshore-offshore diversity.

Govaere's (1975) data also suggest a more abundant and more diverse macofauna on the west coast than on the east coast, as pictured in figure 9.

Table 2. Summary of the literature about the macrobenthos of the BCS with indication of the average density (numbers/m^2), the average biomass (mg ADW/m^2), the diversity indices (N_0, N_1, and Shannon-Weaver H'), the number of stations per zone, the number of replica taken, the mesh size (mm) of the sieve used and, the moment of fixation for each study (i.e. before or after sieving of the sample).

Reference	**zone**	**dens (#/m²)**	**biom (mg adw/m²)**	**N_0 area**	**N_0 station**	**N_1**	**H'**	**# stations**	**# replicas**	**Sieve used**	**Fixation**
Govaere 1975	2	549.0		57	24.1			7	4-5	1	After
Vanosmael 1977	1	4023.3	5597.6	43	15.0		2.01	8	3	0.87	Before
Govaere 1978	1	242.0	1337.0		3.9		1.35	13	2-8	0.87	Before
	2	925.8	2677.5		10.6		2.27	10			
	4	1940.7	4305.8		16.3		2.90	1			
	5	1078.6	1379.4		19.0		3.30	2			
	7	797.5	1078.3		14.2		2.98	2			
	9	4003.6	2935.3		33.0		3.66	1			
Rappé 1978	3	413.1	474.5	53	13.0			10	2	0.87	Before
Van Steen 1978	2	1865.3	10741.8	19	7.6			12	3	0.87	Before
Kerckhof 1980	1	842.2		39	17.0		2.26	3	2-3	0.87	Before
	2	3418.8		57	28.0		2.49	2	2-3	0.87	Before
Meheus 1981	3	1505.0	756.0	34	8.5			6	3	0.87	Before
	3	577.1		45	14.9			10	3	0.87	Before
	5	2171.5	2892.8	29	10.3			4	3	0.87	Before
De Rycke 1982	3	3089.3	1440.5	36	16.7			6	3	0.87	Before
	5	1530.5	2293.8	29	20.3			4	3	0.87	Before
Vanosmael et al. 1982	3	4908.0		73	27.0			10	3	0.87	Before?
Arellano 1995	1	2718.2						2	5	1	Before
	2	1375.2						1	5	1	Before
Coenjaerts 1997	3	1163.0		39	12.0	5.93		42	1	1	After
	4	593.1		54	11.5	6.28		12	1	1	After
	5	835.3		47	10.1	5.73		20	1	1	After
	7	145.4		32	5.5	3.77		21	1	1	After
Philips 1998	3	3009.1		87	19.4	6.46	1.68	103	1	1	After
Degraer et al. 1999a	2			71	5.4	9.80	1.58	40	1	1	After

BIODIVERSITY OF THE BENTHOS AND THE AVIFAUNA OF THE BELGIAN COASTAL WATERS

NUMBER OF MACROBENTHOS STATIONS PER ZONE

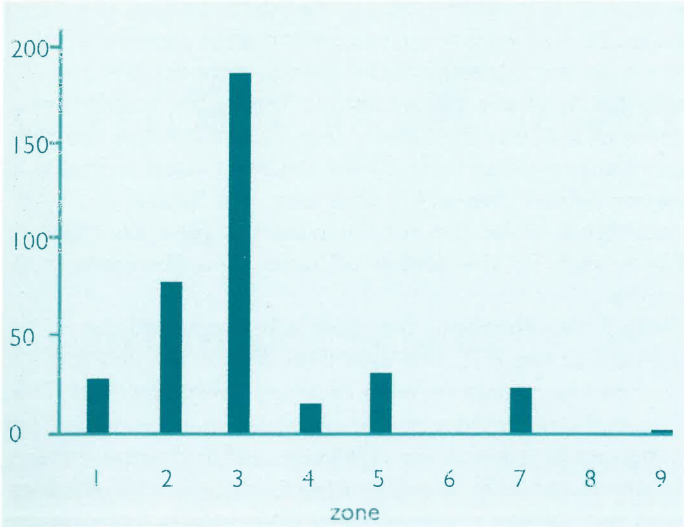


Figure 7. Macrobenthos research intensity on the BCS.

In contrast to the results obtained with the meiofauna and the hyperbenthos data (see chapter 5), the average number of recorded species per station for each zone indicates no trend when averaging all studies. Again, the studies of Govaere (1978) and Coenjaerts (1997), the only two studies that sampled over a wide geographical range on the BCS, contradict this.

AVERAGE MACROBENTHOS DENSITY PER ZONE

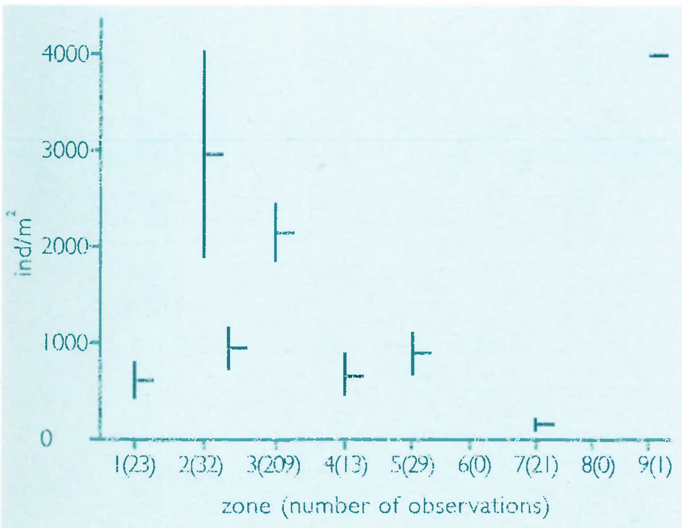


Figure 8. Average macrofauna density (± standard error) for each of the nine zones. The total number of observations is indicated between brackets.

AVERAGE NUMBER OF MACROBENTHOS SPECIES PER ZONE

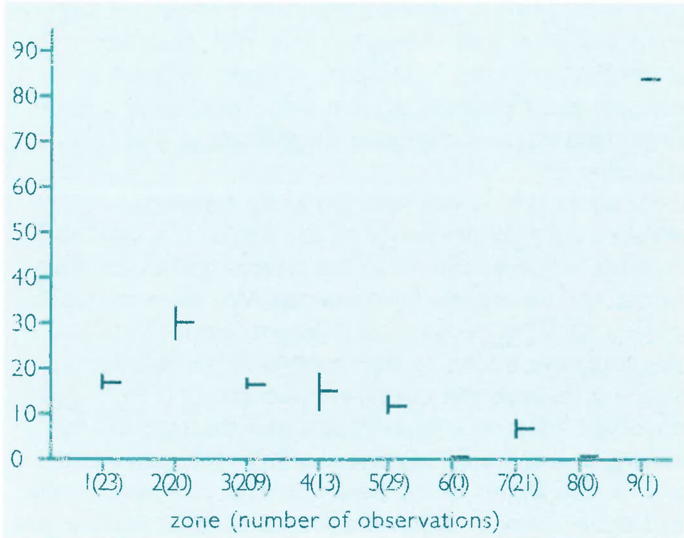


Figure 9. Average number of macrobenthos species (± standard error) per station per zone. The total number of observations is indicated between brackets.

4.3. Discussion

The sand and gravel mining activities around the Flemish Banks (especially the Kwinte Bank) and the Zeeland Banks and the former industrial waste dumping zone around the Zeeland Banks explain the concentration of macrobenthos studies in these areas.
Reports on the effect of dumping of industrial wastes (titaniumdioxide, thiocarbamate and aniline) on the benthos unfortunately yielded no information on the structural diversity of the benthic communities (Maertens 1984, 1987, 1989).
Vandamme & Heip (77) and Govaere et al. (1980) divided the BCS into three benthic regions: a coastal, a transitional and an open sea region, each with their own communities. The average biomass and the average diversity of the macrofauna increased between the coast and the open sea. Changes in sediment characteristics and organic matter content of the sediments cause the differences in the composition of the benthos communities (Govaere 1975, Govaere et al. 1980, Willems et al. 1982). The inshore-offshore gradient in organic matter content of the sediments correlates well with a parallel gradient in phytoplankton production on the BCS (Govaere et al. 1980). Govaere et al. (1977a) divided the Belgian-Dutch coastal waters in a similar fashion.

Up to date Govaere (1978), Govaere et al. (1977a) and Coenjaerts (1997) are the only studies that covered large parts of the BCS. The contrasting results of both authors can be explained by the sampling methodology. Govaere (1978) used a smaller mesh size and his publication did not allow omitting the smaller size fraction from our analyses. The coarser offshore sediments offer larger interstitial spaces allowing more niches and thus higher species richness. Govaere (1978) indeed reports a fair number of small interstitial polychaete species which could not have been found without the size fraction of 250µm. The total benthic diversity (N_0 per station) likely follows the trend reported by this author but it should be kept in mind that when considering the true macrobenthos organisms only, Coenjaerts' picture might reflect the macrobenthos diversity pattern. Yet, in that study samples were fixed after sieving causing significant loss of individuals.

Coenjaerts (1997) has sampled along transects perpendicular to the length of the banks. This way, each transect includes stations in the deeper gullies, on the slopes and on the shallow bank top. We were unable to distinguish samples taken at different depth strata and this may have added to the result of lower species richness towards the open sea. Coenjaerts (1997) indeed observed a positive relation between the macrofauna density and the diversity and depth. In the gully habitat and on the slopes of the banks coarser sediments occur and richer communities were found. Another feature was that the communities of the north-west side of the bank differed from those found at the south-east side.

The plume of the Westerschelde estuary negatively influences the benthic life on the eastern coast. The deposition of very fine and contaminated sediments by the river decreases both the species richness and the abundance of the macrobenthos. The higher standard error of the average density (Fig. 8) and average species number per station (Fig. 9) for the west coast indicates a higher habitat diversity in that area. The habitat heterogeneity for the inshore waters is generally much higher than for the deeper offshore areas (Govaere et al. 1980).

Table 2 only mentions the studies that covered the subtidal of the BCS. The intertidal of beaches and the surfzone have only recently received some attention. The beach macrobenthos can be divided into a low water and a high water community (De Neve 1996, Mouton 1996, Elliott et al. 1997). The former assemblage bears affinities with the subtidal macrobenthos of the coastal sandbanks (Degraer et al. 1999b). The intertidal position determines the structure of the communities but groins locally disturb the pattern (De Neve 1996).

The functional diversity of the macrobenthos has been examined by Govaere et al. (1977b). These authors distinguish a coastal benthic zone with a high productivity and food web of a relative low complexity from an offshore benthic zone with a low productivity and a higher complexity in food web structure. Both zones correspond with the coastal and open sea zones identified by Govaere et al. (1977a, 1980).