Macrozoobenthos of the sandy littoral zone of the Gulf of Gdańsk

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Abstract

The aim of the study was to determine the distribution, composition and seasonal variability of the macrozoobenthos in the sandy littoral zone of the Gulf of Gdańsk including the inner part of Puck Bay. The results of qualitative and quantitative investigations of the benthic fauna are presented. Material was collected every month from October 1992 to December 1993 at 10 stations from 0.5 to 1 m depth. A total of 23 species and 5 higher macrofaunal taxa were identified. At each station 2 samples were collected with an 80 cm^2 Morduchaj–Boltovski pipe-grab. The average abundance and wet weight of particular taxa were calculated. The analyses showed that in the shallow-bottom zone the most diverse and abundant bottom fauna occurred at the stations situated in the inner Puck Bay. The composition was least diverse at the stations located in the estuary of the river Vistula (Świbno, Mikoszewo). Polychaeta and Bivalvia constituted up to 97% of the bottom fauna biomass; *Nereis diversicolor* and *Mya arenaria* were the dominant species.

1. Introduction

The Gulf of Gdańsk has frequently been the subject of marine biological and hydrological research. Hagmeier (1926, 1930) published the first numerical results concerning the macrobenthos, and these were followed by the papers of Mulicki (1938), Demel and Mańkowski (1951) and Demel and Mulicki (1954). Subsequent contributors to the studies of the macrobenthic fauna of the area were Jażdżewski (1962, 1965, 1971), Wołowicz (1977),

Legeżyńska and Wiktor (1981), Ostrowski and Żmudziński (1982), Wenne and Wiktor (1982), Herra and Wiktor (1985), Wiktor (1985) Kotwicki *et al.* (1993), Wołowicz *et al.* (1993) and many others. Biologists have paid the greatest attention to Puck Bay, the western part of the Gulf of Gdańsk. However, numerical studies of the zoobenthos have been limited to the deeper regions of the Gulf of Gdańsk (*e.g.* Żmudziński, 1967). As a result, our knowledge of the density of the macrofauna in the littoral sediments is still limited, not to mention the question of seasonal changes in the abundance, biomass and taxonomic composition of the Baltic sandy littoral, the answers to which are completely unknown, except for a recent study by Haque *et al.* (1996). The aim of the present work was to update knowledge of the zoobenthos structure in the Gulf of Gdańsk. While the shores of this bay are a favourite holiday destination on the Polish coast, the area is also a centre of industry (ports, fisheries), and pollutant discharges due to urban construction and from the river Vistula are considerable. It therefore comes as no surprise that the HELCOM recommendations (1993), which emphasised the necessity of coastal studies in the Baltic, named the Gulf of Gdańsk among selected key areas (Andrulewicz, 1996).

2. Material and methods

The study area comprised the coastal waters of the Gulf of Gdańsk. Ten sampling stations were situated in shallow waters from 0.5 to 1 m depth – five in inner Puck Bay, two in outer Puck Bay and three at the mouth of the Vistula.

The material was collected every month from October 1992 to December 1993. At each station, two samples were collected with an 80 cm^2 Morduchaj–Boltovski pipe-grab. These were sifted through a 0.5 mm mesh sieve, then preserved in 4% formaldehyde solution. The species composition, abundance and biomass (wet formalin weight) were determined; bivalves were weighed with shells. Abundance and biomass were expressed per m^2. The values of quantitative and qualitative analyses were calculated as an annual average for each station.

The seasonal variations in abundance and biomass of the macrozoobenthos in shallow water (<1 m depth) were calculated for particular seasons:

- spring – March, April, May
- summer – June, July, August
- autumn – September, October, November
- winter – December, January, February

3. Results

A total of 20 species, 2 genera (*Gammarus* sp., *Hydrobia* sp.) and 3 higher taxa (Oligochaeta, Hirudinea, Chironomidae) were identified. In the shallow coastal zone the fauna was most diverse at the inner Puck Bay stations, except for the 'corner' of Puck Bay (near Władysławowo).The composition was least diversified at the Vistula estuary stations (near Świbno). The number of taxa found ranged from 4 in the Świbno I area to 21 off Kuźnica. The species composition, together with the average abundance and biomass of particular taxa (indiv. m^{-2}) at the sampling points are shown in Tab. 1 and 2, the mean abundance (indiv. m^{-2}) and proportions of the taxa in the study area in Fig. 1, and the average biomass (g m^{-2}) and proportions of the taxa there in Fig. 2. Generally speaking, Oligochaeta, Polychaeta and Crustacea were the most numerous with mean concentrations reaching several thousands of specimens per m^2. The mean annual biomass of macrozoobenthos ranged from 0.6 g m^{-2} (near Mikoszewo) to 373 g m^{-2} (near Chałupy) (Tab. 2). The highest benthic macrofauna biomasses were recorded on the shallow bottom of inner Puck Bay along the Hel Peninsula (near Chałupy and Kuźnica), and off Osłonino and Rzucewo. At the mouth of the Vistula, biomasses were the lowest, especially in the Mikoszewo area, varying from 0 to 3.1 g m^{-2}. The most important animal group in the shallow waters of the Gulf of Gdańsk were Polychaeta, the main component of which was *Nereis diversicolor*. Polychaetes were the most widespread, being present in samples from all the stations with wet weights ranging from 0.1 g m^{-2} in the Świbno area to 170 g m^{-2} off Chałupy. They were followed by four bivalve species: *Mya arenaria*, *Macoma balthica*, *Cerastoderma glaucum* and *Mytilus trossulus*. The percentage of bivalves in the zoobenthos biomass varied from 0% (near Władysławowo) to 69% (near Rzucewo); only off Rzucewo and Kuźnica were they dominant. The average annual biomass of Crustacea ranged from 0.3 to 26.7 g m^{-2}, making up *ca* 10% of the macrozoobenthos. Among the Gastropoda, *Hydrobia* sp. was the most important taxon (biomass 0.1–31.1 g m^{-2}), occurring at all stations other than those in the Vistula estuary. Oligochaeta and Chironomidae larvae were the main components of the bottom fauna in the shallow waters in the Vistula estuary (Świbno).

Seasonal changes in zoobenthos abundance and biomass were also noted, varying at particular stations. Polychaeta and Bivalvia were predominant in the biomass throughout the year except off Świbno, where Chironomidae were dominant in both abundance and biomass. Seasonal variations in total abundance and biomass were subject to similar changes at Świbno I, Świbno II, Kuźnica and Władysławowo, where maximum values were usually recorded in autumn. During this season, macrofauna was most

Table 1. Species composition, average abundance [indiv. m^{-2}] of particular taxa in the study areas

Taxa \ Station	Jurata	Kuźnica	Chałupy	Władysławowo	Rzucewo	Osłonino	Orłowo	Świbno II	Świbno I	Mikoszewo
Oligochaeta	3470	283	4348	3765	4189	2769	367	1610	11895	16
Polychaeta	2811	6838	6233	3332	4164	2012	585	89	9	32
Pygospio elegans	–	3597	19	–	19	–	–	–	–	–
Streblospio shrubsoli	–	16	–	–	1859	13	–	–	–	–
Nereis diversicolor	2770	3226	6213	3332	2279	1999	580	25	9	32
Marenzeleria viridis	41	–	–	–	6	–	5	64	–	–
Crustacea	86	12324	1490	318	1178	2756	2747	496	54	16
Idotea chelipes	–	95	274	–	19	19	–	25	–	–
Idotea balthica	–	42	64	–	64	–	–	–	–	–
Corophium volutator	52	3401	76	307	89	248	9	19	–	–
Cyathura carinata	17	1050	134	6	611	586	9	6	–	–
Gammarus sp.	–	64	318	–	45	95	–	229	54	–
Sphaeroma hookeri	17	1443	611	–	331	1808	–	–	–	–
Bathyporeia pilosa	–	32	–	6	19	–	2640	–	–	–
Neomysis integer	–	6196	6	–	–	–	89	216	–	16
Asellus aquaticus	–	–	6	–	–	–	–	–	–	–
Bivalvia	47	504	592	0	509	216	51	903	0	5
Cardium glaucum	–	202	477	–	223	140	9	–	–	–
Macoma balthica	6	122	6	–	76	6	19	–	–	–
Mya arenaria	6	117	102	–	210	70	9	903	–	–
Mytilus trossulus	35	64	6	–	–	–	14	–	–	–
Dreissena polymorpha	–	–	–	–	–	–	–	–	–	5
Gastropoda	98	1639	2508	613	2075	1992	264	45	0	0
Lymnea peregra	–	212	–	–	–	–	–	–	–	–
Theodoxus fluviatilis	23	133	6	–	6	19	–	–	–	–
Potamophyrgus jenkinsi	–	16	535	17	–	–	–	13	–	–
Hydrobia sp.	75	1279	1967	596	2069	1973	264	32	–	–
Varia	53	6	127	110	25	50	25	2856	4747	16
Chironomidae	17	6	25	64	25	50	25	2850	4747	16
Hirudinea	36	–	102	46	–	–	–	6	–	–

Table 2. Species composition, average biomass [g m^{-2}] of particular taxa in the study areas

Taxa \ Station	Jurata	Kuźnica	Chałupy	Władysławowo	Rzucewo	Osłonino	Orłowo	Świbno II	Świbno I	Mikoszewo
Oligochaeta	3.124	0.205	3.449	2.988	3.239	2.391	0.266	1.156	10.624	0.011
Polychaeta	109.75	130.65	170.36	153.25	74.05	85.55	23.93	2.78	0.04	0.21
Pygospio elegans	–	2.675	0.0126	–	0.014	–	–	–	–	–
Streblospio shrubsoli	–	0.005	–	–	0.553	0.007	–	–	–	–
Nereis diversicolor	106.093	127.970	170.347	153.250	73.246	85.546	23.697	2.085	0.041	0.205
Marenzeleria viridis	3.654	–	–	0.238	–	0.237	0.693	–	–	–
Crustacea	0.25	48.10	13.41	0.75	5.91	13.89	4.73	3.81	1.04	0.26
Idotea chelipes	–	0.512	2.256	–	0.180	0.955	–	0.273	–	–
Idotea balthica	–	0.289	0.537	–	1.339	–	–	–	–	–
Corophium volutator	0.094	2.688	0.115	0.732	0.129	0.217	0.005	0.017	–	–
Cyathura carinata	0.106	4.086	0.607	0.012	2.296	2.512	0.020	0.025	–	–
Gammarus sp.	–	3.676	4.556	–	0.467	3.799	–	2.446	1.038	–
Sphaeroma hookeri	0.054	12.311	5.216	–	1.473	6.409	–	–	–	–
Bathyporeia pilosa	–	0.045	–	0.005	0.022	–	3.896	–	–	–
Neomysis integer	–	24.494	0.119	–	–	–	0.805	1.052	–	0.261
Asellus aquaticus	–	–	0.009	–	–	–	–	–	–	–
Bivalvia	5.36	153.27	170.36	0.00	203.94	29.36	12.67	2.15	0.00	0.09
Cardium glaucum	–	31.103	66.512	–	50.230	6.443	0.405	–	–	–
Macoma balthica	1.451	19.058	0.554	–	15.654	5.660	6.680	–	–	–
Mya arenaria	2.016	93.105	102.951	–	138.053	17.261	0.114	2.148	–	–
Mytilus trossulus	1.895	10.001	0.346	–	–	–	5.473	–	–	–
Dreissena polymorpha	–	–	–	–	–	–	–	–	–	0.094
Gastropoda	0.44	28.55	14.35	3.35	6.10	11.28	1.80	0.15	0.00	0.00
Lymnea peregra	–	14.711	–	–	–	–	–	–	–	–
Theodoxus fluviatilis	0.196	4.142	0.256	–	0.043	0	–	–	–	–
Potamophyrgus jenkinsi	–	0.020	2.685	0.090	–	–	–	0.062	–	–
Hydrobia sp.	0.242	9.679	11.411	3.255	6.056	11.150	1.796	0.083	–	–
Varia	0.35	0.01	0.93	0.25	0.20	0.18	0.09	27.55	21.88	0.03
Chironomidae	0.272	0.009	0.039	0.099	0.199	0.180	0.087	27.497	21.877	0.025
Hirudinea	0.082	–	0.887	0.149	–	–	–	0.055	–	–

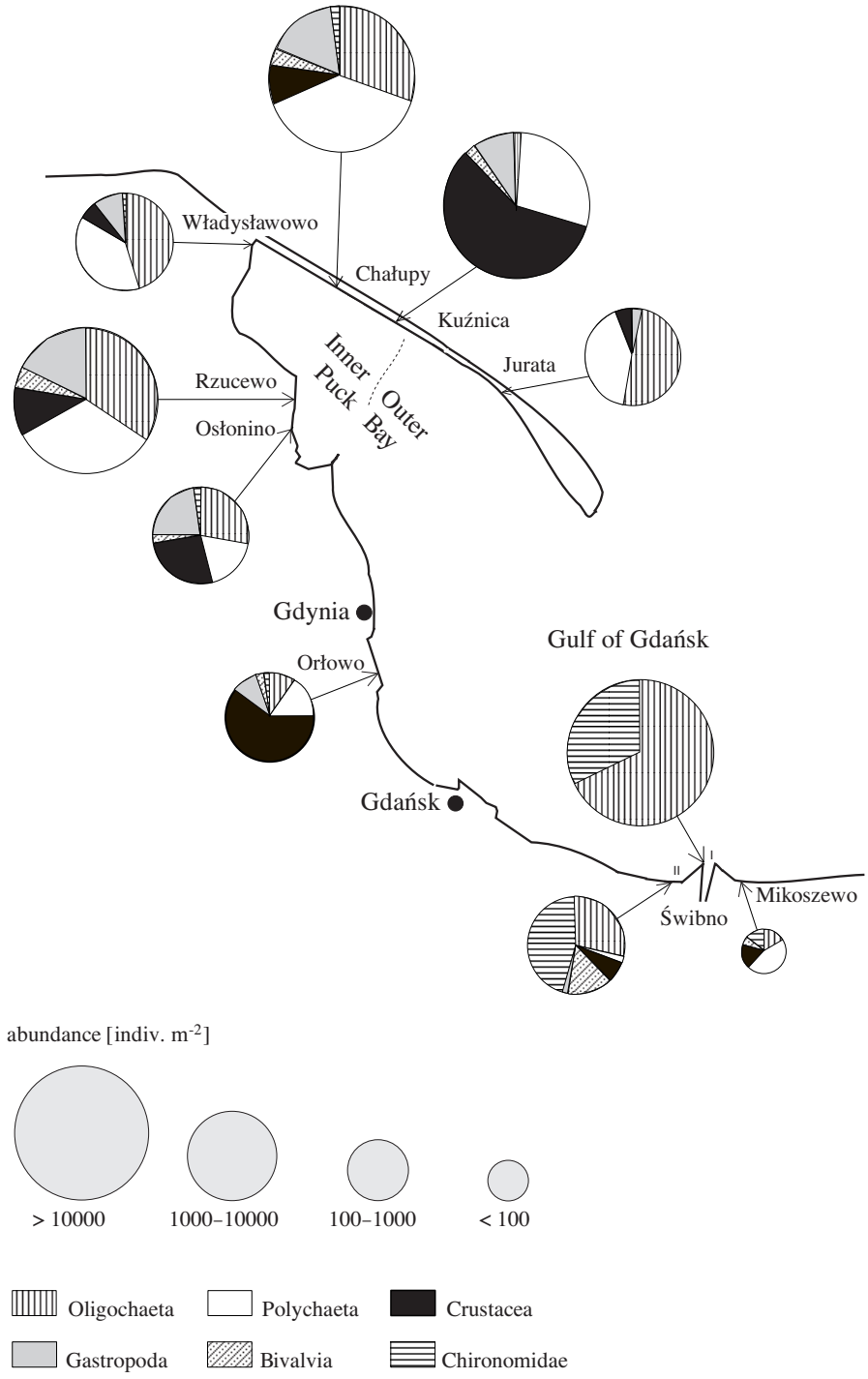


Fig. 1. Percentage of the average abundance of particular taxa in the study areas

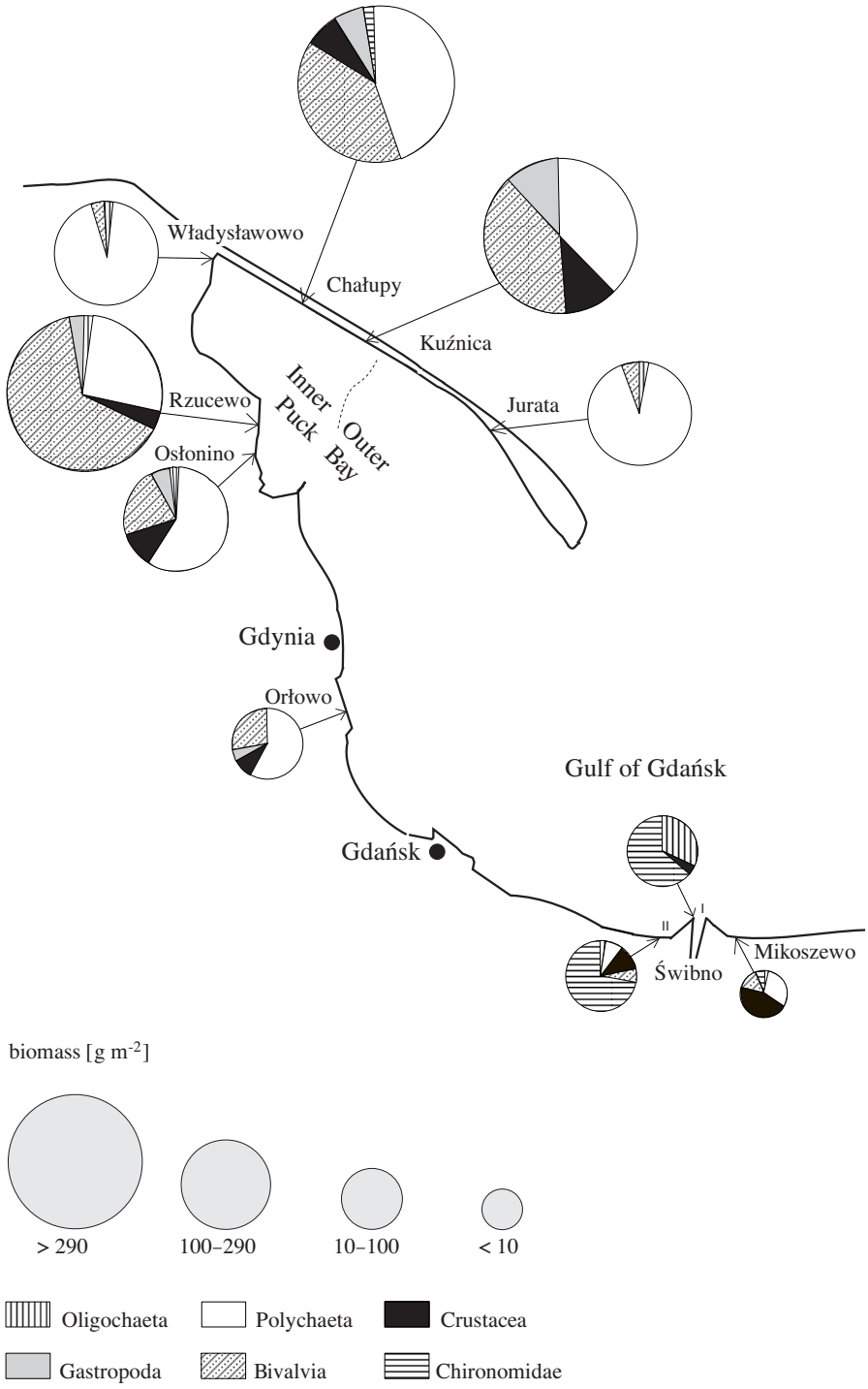
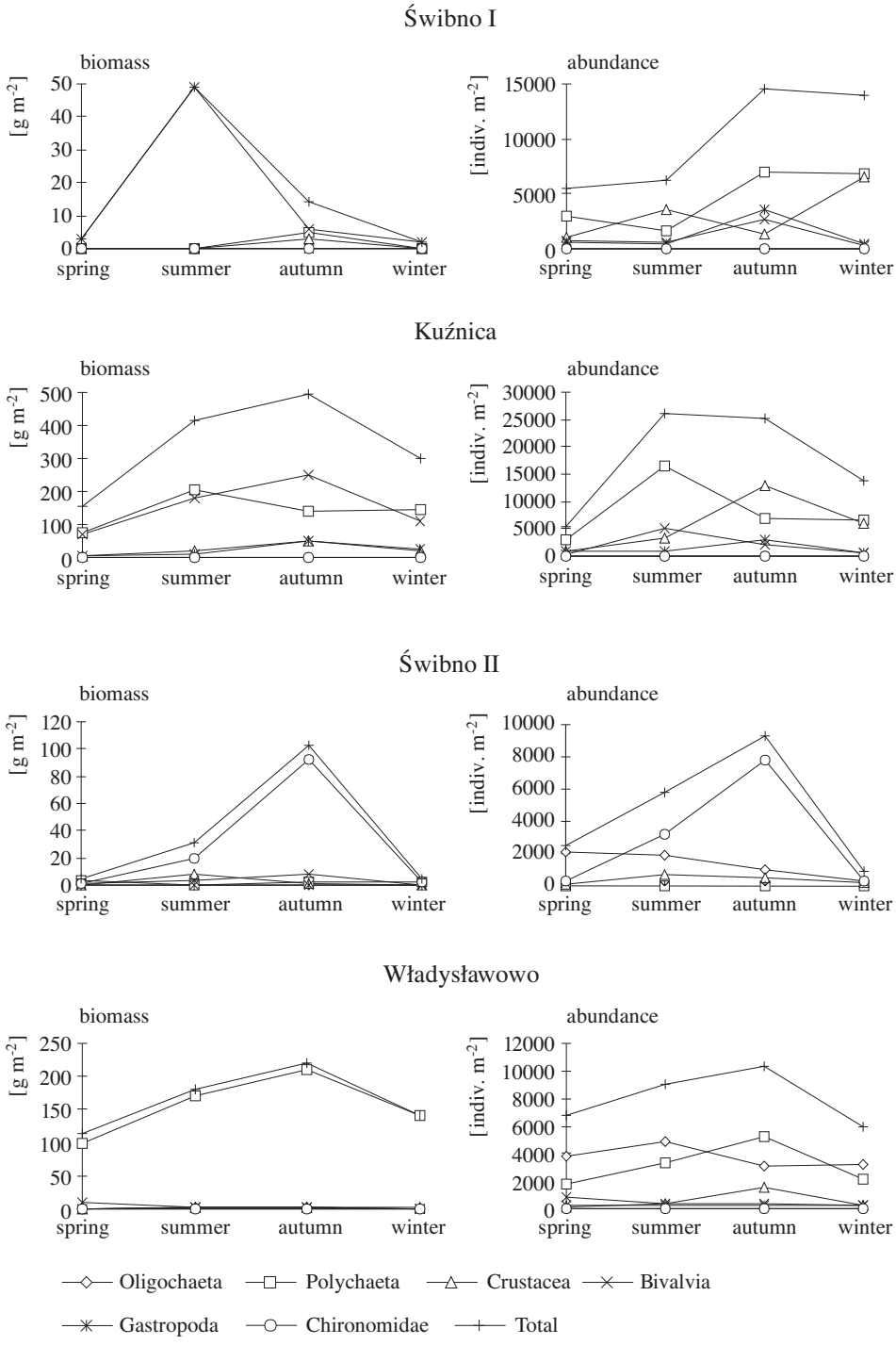


Fig. 2. Percentage of the average biomass of particular taxa in the study areas

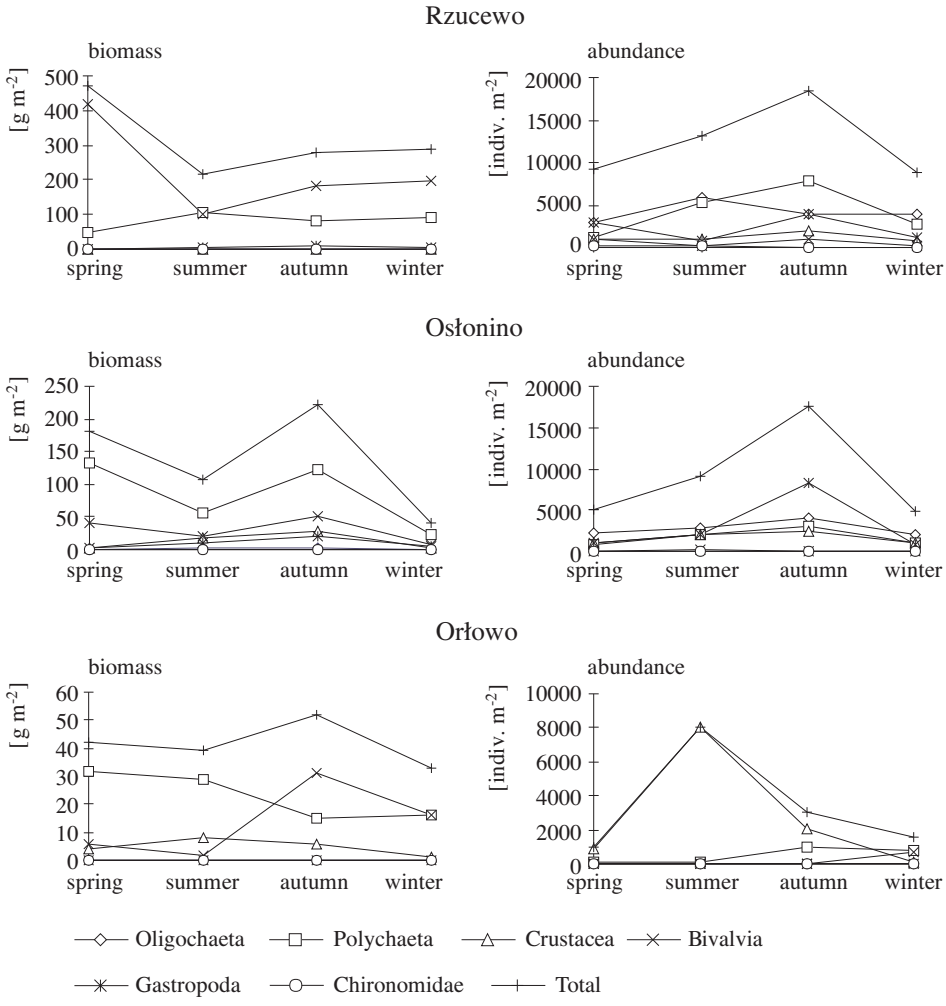
a


Świbno I
biomass
[g m-2]
50
40
30
20
10
0
spring
summer
autumn
winter
abundance
[indiv. m-2]
15000
10000
5000
0
Kuźnica
500
400
300
200
100
30000
25000
20000
15000
10000
5000
Świbno II
120
100
80
60
40
20
8000
6000
4000
2000
Władysławowo
250
200
150
12000
Oligochaeta
Polychaeta
Crustacea
Bivalvia
Gastropoda
Chironomidae
Total

abundant off Kuźnica (26 000 indiv. m^{-2}), where the biomass reached 500 g m^{-2}. Two taxa jointly dominated the abundance in both the Kuźnica and the Władysławowo areas: Polychaeta and Oligochaeta off Władysławowo, Polychaeta and Crustacea off Kuźnica (Fig. 3a).

A different situation occurred off Rzucewo, Osłonino and Orłowo, where two biomass maxima (spring and autumn) but only one abundance maximum (autumn – in summer in the Orłowo area) were recorded, and testified to the fact that the individual weight of autumn specimens was very small. In terms of abundance the macrozoobenthos off Orłowo was dominated by Crustacea (*B. pilosa*) (95% in summer) (Fig. 3b).

b



c

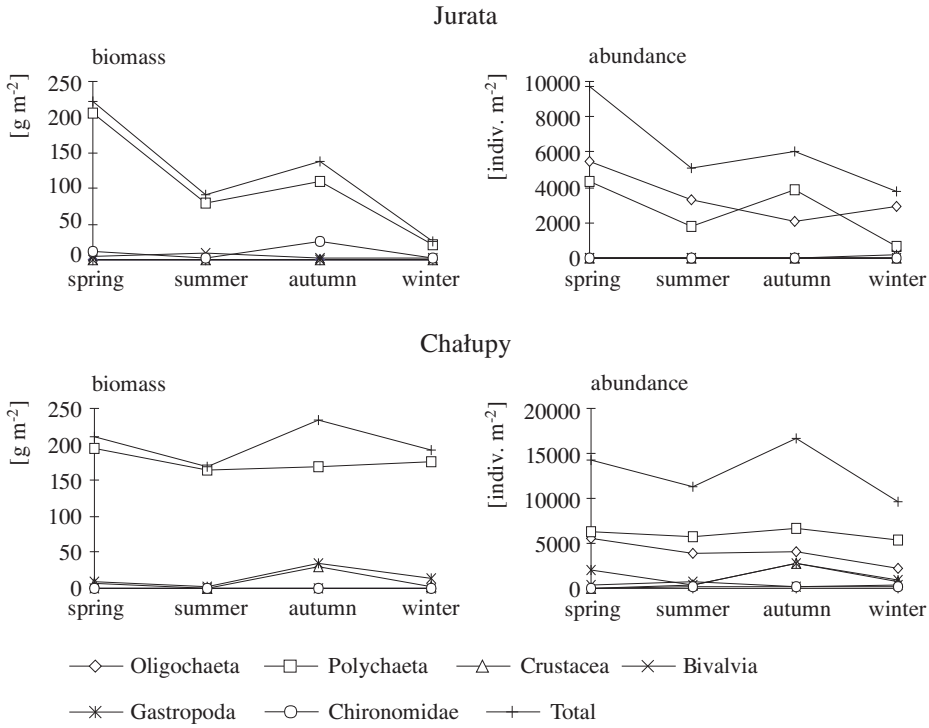


Fig. 3. Seasonal fluctuations in the abundance and biomass of particular zoobenthos taxa

In the Chałupy and Jurata areas the macrobenthos abundance and biomass peaked in spring and autumn. Throughout the year both parameters were dominated by Polychaeta, although the abundance of Crustacea occasionally reached notable values (Fig. 3c). In the Mikoszewo area, macrofauna was come across only occasionally and in very low densities, thus no seasonal pattern could be deduced.

4. Discussion

Investigations of the bottom fauna in the coastal zone of the Gulf of Gdańsk carried out in 1992–1993 indicated considerable differences in the benthos composition of this region. These differences are apparent in the structure not only of the macrozoobenthos (percentage of specimens of particular species), biomass and abundance but also of the bottom productivity. They are caused both by the nature and configuration of the bottom character and by the direct influence of the river Vistula and local sewage discharges.

The most abundant and diversified macrozoobenthos was observed in inner Puck Bay, where the remains of underwater meadows can still be found. A different situation obtained in the 'corner' of Puck Bay near Władysławowo owing to the increasing run-off of nutrients and organic substances from the land (Jażdżewski, 1965). Bivalves did not occur there; Crustacea and Gastropoda were of no significance. 96% of the macrozoobenthos biomass comprised Polychaeta. The position was similar off Jurata, where the biomass of *N. diversicolor* exceeded 92% of the total benthic biomass.

In comparison with earlier investigations (Ostrowski and Żmudziński, 1982; Kotwicki *et al.*, 1993), significant changes have taken place. The most important of these is the considerable fall in abundance and biomass of bivalves, especially *C. glaucum* and *M. trossulus*, in the shallow water (< 1 m depth) of the Gulf of Gdańsk. A similar situation was found in the coastal zone of Puck Bay in the neighbourhood of the Swarzewo sewage treatment plant (Wołowicz *et al.*, 1993; Kotwicki *et al.*, 1993).

In the study area *N. diversicolor* and *M. arenaria* constituted up to 97% of the bottom fauna biomass. The most numerous taxa were Oligochaeta, Crustacea and Gastropoda not being of any importance in the biomass of the benthic fauna.

B. pilosa was the main component of the macrozoobenthos in the Orłowo area, where its abundance ranged from 127 to 16 042 indiv. m^{-2}. This was because of the suitably sandy sediment and the strong, frequent changes of current direction in the shallow (0–2 m) coastal zone (Żmudziński, 1978; Ostrowski and Żmudziński, 1982).

Streblospio shrubsoli was recorded at three stations in Puck Bay. Legeżyńska and Wiktor (1981), Ciszewski *et al.*, (1992), Osowiecki (1995) did not find this species in the Gulf of Gdańsk at any of the stations they investigated.

Asellus aquaticus was reported but sporadically in the Chałupy area. In the 1960s, their abundance made up 89% of the benthos composition (Jażdżewski, 1962). Klekot (1980) states that by 1971 *A. aquaticus* had become rare both on plants and on the bottom. In 1977–1978 Wenne and Wiktor (1982) encountered this species sporadically. In 1978 Błędzki and Kruk-Dowgiałło (1983) did not find *A. aquaticus* at any of 57 sampling points situated in Puck Bay.

Lymnaea peregra f. balthica used to be very common, reaching up to several thousands of specimens per m^2 in the coastal zone of Puck Bay (Żmudziński, 1967). Now, *L. peregra* was noted only off Kuźnica and the abundance of this snail was very much reduced.

A very important, new component of the macrozoobenthos in the Gulf of Gdańsk is *Marenzelleria viridis* [Verril 1873], previously known as *Scolecolepides viridis*. In 1988 this species was reported in Polish inshore waters. It is a common estuarine polychaete inhabiting the Atlantic coast of North America, most abundant in intertidal sands in parts of estuaries with reduced salinity (Gruszka, 1991). In the present study polychaete specimens identified as *M. viridis* were found off Jurata, Orłowo, Świbno and Rzucewo with a maximum biomass of 30 g m^{-2}. *M. viridis* has become a new important shallow-water component of the Gulf of Gdańsk.

The seasonal fluctuations in the annual macrobenthos biomass and abundance at Świbno I, Świbno II, Władysławowo, Kuźnica were characterised by an autumn peak. Spring and autumn biomass peaks and an autumn abundance peak were noted at Rzucewo, Osłonino and Orłowo. At Jurata and Chałupy two abundance peaks (spring and autumn) and one biomass maximum were recorded. These variations are related to the biological cycle of shallow-water zoobenthic species, especially that of *N. diversicolor* (Bogucki, 1951; Wołowicz, 1977). Polychaeta (*N. diversicolor*) dominated the bottom fauna biomass throughout the year in the study area except in the Świbno area, where chironomids were predominant.

5. Conclusions

Benthic macrofauna was collected from shallow areas (0.5–1 m) every month from October 1992 to December 1993. A total of 20 species, 2 genera (*Gammarus* sp. and *Hydrobia* sp.) and 3 higher taxa (Oligochaeta, Hirudinea and Chironomidae) were found in samples of the macrozoobenthos.

The benthic macrofauna was most abundant and diversified at the stations in the inner Puck Bay. The shallow waters of Puck Bay were characterised not only by a considerably higher biomass of bottom fauna but also by a greater species diversity than the rest of the Gulf of Gdańsk.

The species composition in the zone adjacent to the Vistula estuary is different; its biomass, however, is very low. This was due to the direct influence of Vistula water: salinity decrease, variable current direction, suspended matter and anthropogenic pollution (Herra and Wiktor, 1985).

Making up 97% of the bottom fauna biomass, Polychaetes (*N. diversicolor*) and bivalves (*M. arenaria*) were predominant there. The total bivalve biomass in the coastal zone (<1 m depth) was significantly lower than that in the deeper regions of the Gulf of Gdańsk.

The macrobenthos abundance and biomass peaks distinctly in spring and autumn. The bottom fauna biomass was dominated by Polychaeta (*N. diversicolor*) and Bivalvia throughout the year, except in the Świbno area, where Chironomidae were dominant in both abundance and biomass.

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