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**THE NEWCOMER MARENZELLERIA VIRIDIS  
(VERRILL, 1873), ITS DEVELOPMENT AND  
INFLUENCE ON THE INDIGENOUS  
MACROZOOBENTHOS IN A COASTAL WATER OF  
THE SOUTHERN BALTIC**

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**Abstract.** *Marenzelleria viridis* (Verrill 1873), a spionid polychaete that immigrated into brackish water ecosystems of the North Sea and Baltic Sea from North America in the early eighties, has spread rapidly in its European biotopes and is now an dominant element of the fauna in some regions. It was first found in the Darss-Zingst bodden chain, an inland estuary on the south Baltic coast, in 1985. Continuous monitoring from 1992 to 1995 shows that *M. viridis* has continuously spread in these waters and has revealed the effects on the indigenous fauna. The highest abundances and biomasses (about 30,000 ind/m<sup>2</sup> and 400 g wet wt/m<sup>2</sup> [50 g AFDW/m<sup>2</sup>]) were found in the inner part of the estuary (S=3–5‰). Significant positive correlations (abundance and rank correlations) existed between the adult and juvenile subpopulations of *M. viridis* and between juvenile *M. viridis* and chironomids (larvae of the *Chironomus plumosus* and *Ch. halophilus* types). Negative correlations were calculated between the spionid and both *Corophium volutator* and the naidids. The correlations between the spionid and *Hediste diversicolor* are unclear. Unlike adult *M. viridis*, which correlate positively with the nereids, the correlation between juvenile *M. viridis* and nereids appears to be negative. However, neither correlation was significant.

The abundance and biomass data collected for various macrozoobenthos representatives (*Hydrobia ventrosa*, *H. diversicolor*, *C. volutator*, chironomids and oligochaetes) during the present study are compared with those available in the literature to draw conclusions regarding the influence of the new species.

Investigation of the population dynamics of *M. viridis* shows that it has an unusually long life span of 2–3 years. Up to 3 co-existing generations have been observed in a single year.

Key words: bioturbation, establishment, introduction, *Marenzelleria*, population dynamics, relationship.

## Introduction

Colonization of the Baltic Sea, a brackish sea which arose in its present form after the last glaciation and is thus historically quite young, has been a competition among immigrant species from various parts of the world. Ice age relics such as *Saduria entomon* and *Mysis relicta* have been joined during the past centuries particularly by immigrant species from the Pontic-Caspian region (e.g. *Dreissena polymorpha*, *Cordylophora caspia*) and North America (e.g. *Arenomya arenaria*, *Rithropanopeus harrisi*) (Jansson 1994, Leppäkoski 1984). Increasing tourism, aquaculture and worldwide sea transport have led especially in recent years to further immigrations of invasion-like character. The relatively low density of colonization and the stress factor of low, irregularly fluctuating salinities permit primarily brackish water species to find ever new niches.

Two organisms that have immigrated or been imported into the area during the past few years come from North America. *Gammarus tigrinus* (Crustacea, Amphipoda) and *Marenzelleria viridis* (Annelida, Polychaeta) have managed to establish themselves in most coastal Baltic waters and are now the dominant elements of the fauna in several places (e.g. Essink and Kleef 1993, Gruszka 1991, Günter et al. 1995, Lagzdins and Pallo 1994, Olenin and Chubarova 1992, Persson 1994, Rudolph 1994, Zettler 1994, 1995b, 1996, Zettler et al. 1994, Zmudzinsky et al. 1993).

*M. viridis* was found for the first time in the bodden chain south of Darss-Zingst by Bick and Burkhardt (1989). The biology of the species was studied closely in these South Baltic waters from 1992 to 1995, attention being concentrated mainly on population dynamics and influence on the indigenous macrozoobenthos.

## Material and Methods

The investigation area, the bodden chain south of the Darss-Zingst Peninsula, is north-east of Rostock, has a length of about 40 km from west to east and occupies an area of around 200 km<sup>2</sup> (Fig. 1). Its salinity is relatively low (1–10 ‰) and is subject to seasonal and interannual fluctuations owing to freshwater inflows and its open connection to the Baltic Sea. The salinity decreases from east to west, the lowest salinities (1–5 ‰) being measured in the inner parts of the bodden chain (stn. 2). At station 1 it fluctuates between 6 and 10 ‰, and at station 3 it varies between these extremes.

Three samples per station were collected by monthly from 1992 to 1995 using a corer with a cross section of 78.5 cm<sup>2</sup> and a penetration depth of 40 cm. The samples were washed through an 0.3 mm mesh sieve and fixed in 4% borax-buffered formalin. The animals were sorted under a dissecting microscope with a magnification of x10 in the laboratory.

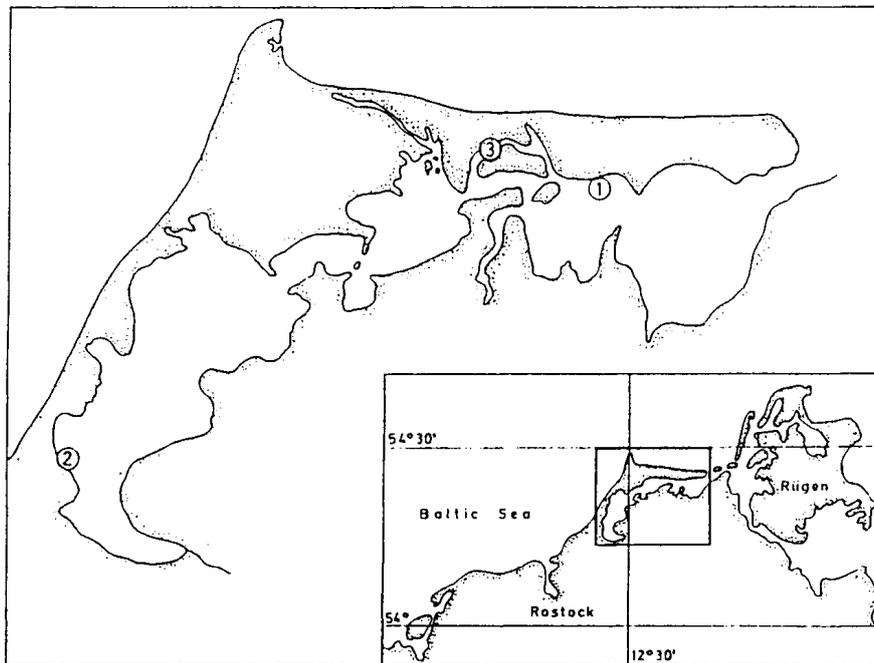


Figure 1. Investigation area Darss-Zingst bodden chain in the north-eastern part of Germany with the stations 1 to 3.

Data taken from the literature were used to ascertain the extent to which the immigration of *M. viridis* has effected the composition and density of the fauna. The results have been presented in numerous publications, diploma and doctoral theses (Arndt 1988, 1989, 1994., Möller 1984, Thiel 1990, Zettler 1993, 1994, 1995a, 1996, Zettler et al. 1994, 1995). From 1969 to 1991, samples were collected using grabs of the Ekmann-Birge (225 cm<sup>2</sup>), Hydrobios (250 cm<sup>2</sup>) and van Veen (600 cm<sup>2</sup>) types penetrating down to 10 cm, and the mesh size used for sieving was 0.5 mm. As a rule, samples were collected only twice a year (spring and autumn).

In all studies, the biomass was measured with an accuracy of 0.1 g wet weight and presented as g/m<sup>2</sup>.

The Spearman rank correlation was used to calculate inter- and intraspecific correlations between juvenile and adult *M. viridis* and *Hydrobia ventrosa*, *Hediste diversicolor*, *Corophium volutator* and chironomids.

## Results

The abundance of *M. viridis* steadily increased at station 1 after its first appearance there in the mid-eighties, rising from a few hundred ind./m<sup>2</sup> at the beginning to a mean density of 8,500 ind./m<sup>2</sup> and a wet weight of 400 g/m<sup>2</sup> in 1994 (Fig. 2). However, this proliferation was not accompanied by a decrease in the numbers of indigenous representatives of the macrozoobenthos.

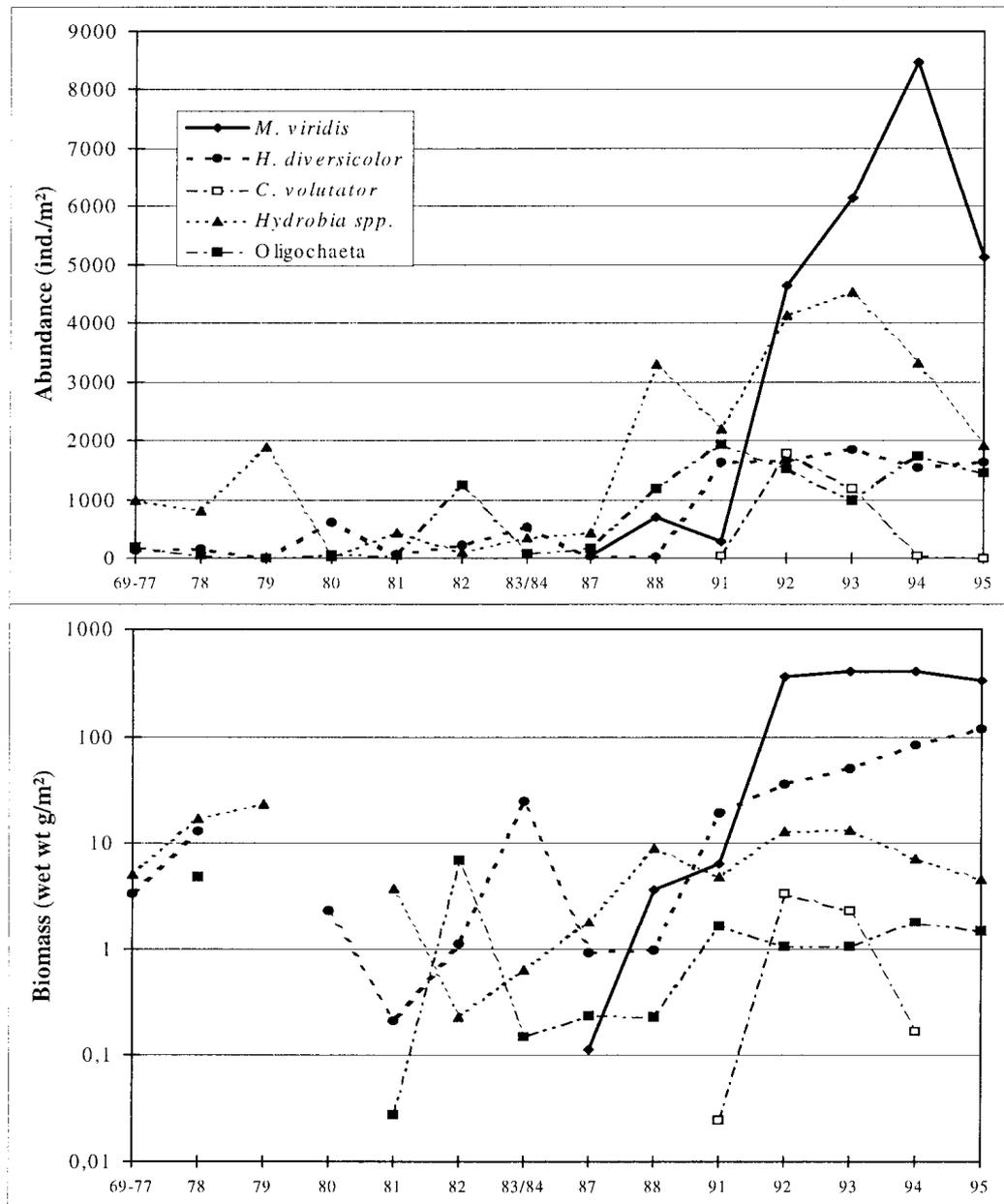


Figure 2. Macrozoobenthos abundances and biomasses in the Darss-Zingst bodden chain at stn. 1 from 1969 to 1995 (September).

Quite the opposite, the abundances and biomasses of most macrobenthic organisms (*H. diversicolor*, *H. ventrosa* and oligochaetes are now considerably higher than 10 or 20 years ago. The abundances of the polychaetes *M. viridis* and *H. diversicolor* have both increased since 1987. In addition, the nereids have spread to the inner parts of the bodden chain. The abundance and biomass of

*H. diversicolor* have increased two to four-fold since 1988: the maximum abundances and biomasses recorded for the period 1969–1988 were 630 ind./m<sup>2</sup> and 25 g/m<sup>2</sup> respectively compared with 2,000 ind./m<sup>2</sup> and 50–100 g/m<sup>2</sup> respectively in 1994. In 1995 all abundances decreased, probably because of low salinities (Fig. 9).

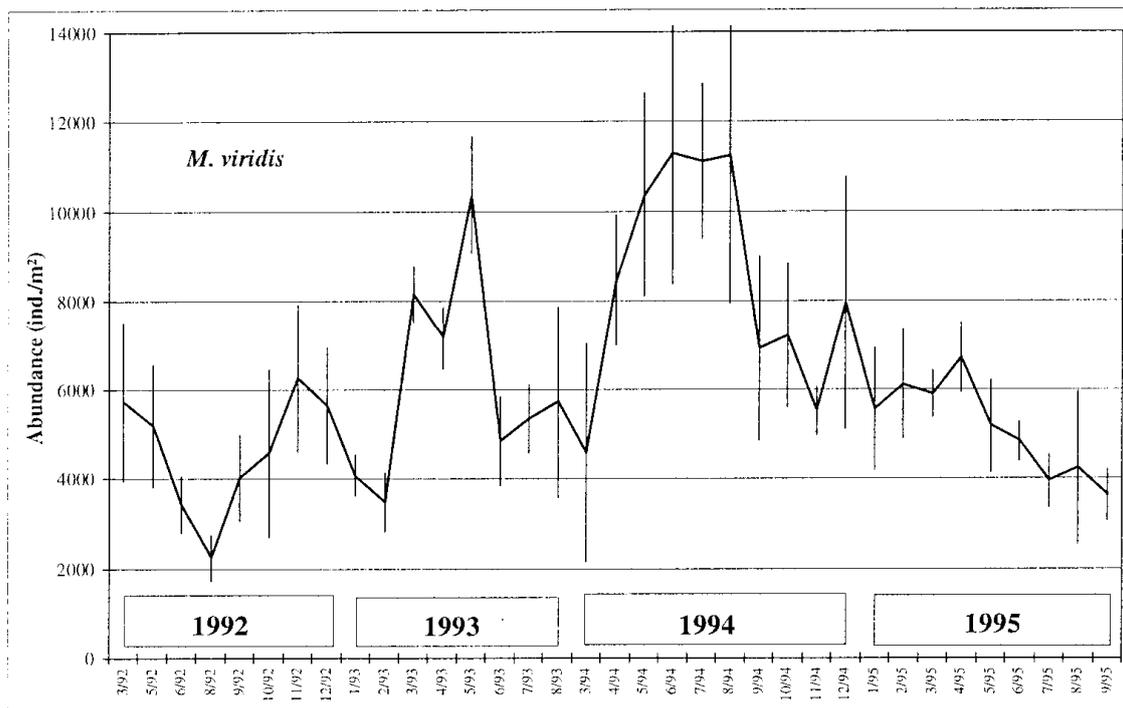


Figure 3. Abundances of *M. viridis* in the Darss-Zingst bodden chain at stn. 1 from March 1992 to September 1995 (means of 3 samples per month with standard deviation).

Fig. 3 shows the development and variability of the abundance of *M. viridis* from 1992 to 1995 (September) at this station. It has varied between 2,000 and 11,000 ind./m<sup>2</sup> during the past 4 years. These increases in abundance continued until mid-1994, when the abundance declined owing to poor reproductive performance.

The relative abundances and biomasses of the macrozoobenthos at station 1 are shown in Fig. 4. The spionid now has a relative abundance of 40 % in terms of individual density and of 80 % in terms of biomass. Other species we found included *Hediste diversicolor*, *Hydrobia ventrosa* and *Tubifex costatus* with relative abundances of 10 to 20%. Altogether, 23 taxa were found at this station (Table 1).

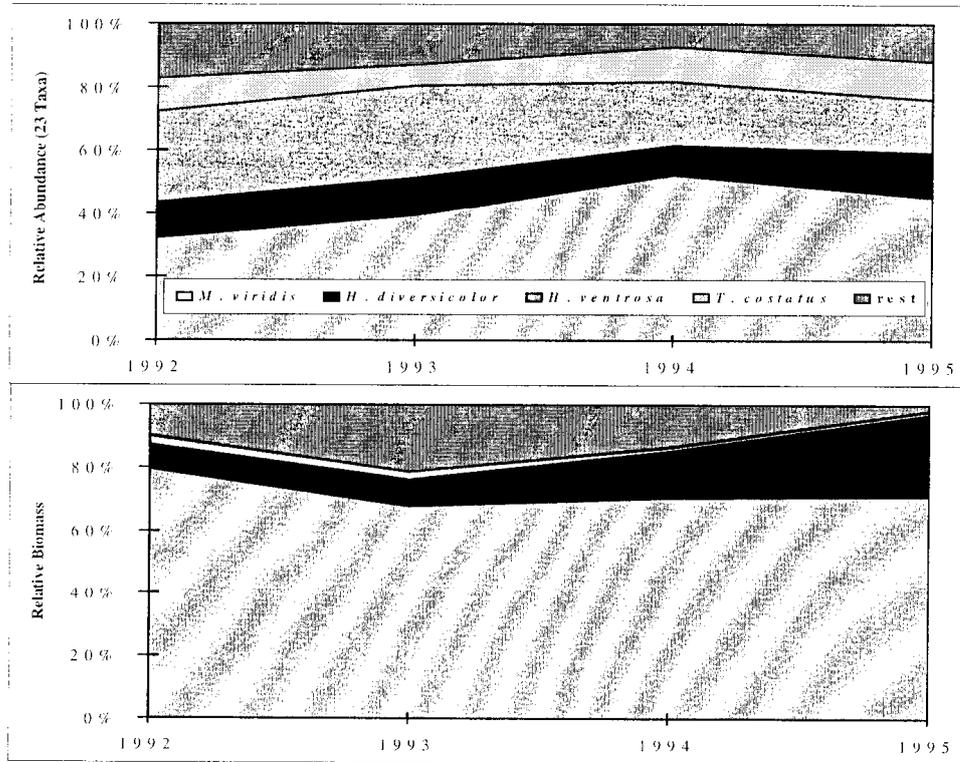


Figure 4. Relative abundances and biomasses (in %) within the macrozoobenthos in the Darss-Zingst bodden chain at stn. 1 from 1992 to 1995.

Table 1

Mean abundances (ind./m<sup>2</sup>) of the taxa found at stations 1, 2 and 3 (annual means from 12 months samples of 3 hauls each), (1995 only until September)

Taxa	Station 1 (23 Taxa)				Station 2 (12 Taxa)				Station 3 (18 Taxa)			
	1992	1993	1994	1995	1992	1993	1994	1995	1992	1993	1994	1995
<i>Arenomya aren.</i>	111	101	132	0	-	-	-	-	0	6	4	0
<i>Bithynia tentac.</i>	-	-	-	-	0	0	0	14	-	-	-	-
<i>Cerastoderma lam.</i>	56	133	38	19	-	-	-	-	-	-	-	-
Chironomidae	32	11	81	137	2436	2711	2088	5704	0	0	151	85
<i>Corophium volut.</i>	1775	1178	47	0	0	0	4	0	2091	8771	722	0
<i>Cyathura carin.</i>	0	5	4	0	-	-	-	-	-	-	-	-
<i>Embletonia pall.</i>	0	0	8	5	-	-	-	-	0	0	8	0
<i>Gammarus spec.</i>	56	27	13	24	11	25	67	75	0	0	0	5
<i>Gammarus tigris.</i>	0	0	0	24	0	0	0	184	-	-	-	-
<i>Hediste diversic.</i>	1656	1852	1533	1618	5	0	0	9	2459	2202	1764	1595
<i>Hydrobia spp.</i>	4137	4522	3312	1911	11	50	21	0	296	441	1760	316
<i>Idotea balthica</i>	220	218	110	146	-	-	-	-	0	21	4	0
<i>Jaera albifrons</i>	11	101	132	61	-	-	-	-	-	-	-	-
<i>Manayunkia aest.</i>	37	16	200	354	-	-	-	-	0	0	0	5

<i>Marenzelleria vir.</i>	4642	6146	8467	5129	1242	8008	27640	4430	1566	2645	2123	2156	
<i>Nais elinguis</i>	0	0	0	28	–	–	–	–	0	0	15	14	
<i>Neanthes succinea</i>	5	80	38	9	–	–	–	–	0	55	31	9	
<i>Paranais litoralis</i>	0	0	0	52	–	–	–	–	323	294	154	75	
<i>Piscicola geom.</i>	0	0	8	0	–	–	–	–	–	–	–	–	
<i>Potamopyrgus ant.</i>	3	11	13	5	0	0	25	5	0	0	19	0	
<i>Prostoma obscura</i>	53	96	204	175	–	–	–	–	34	123	93	146	
<i>Sphaeroma hook.</i>	149	37	55	47	0	0	4	0	0	0	19	0	
<i>Stylaria lacustris</i>	–	–	–	–	0	0	4	33	0	0	58	47	
<i>Theodoxus fluv.</i>	11	32	119	264	–	–	–	–	–	–	–	–	
<i>Tubifex costatus</i>	1510	993	1741	1368	69	67	35	193	0	0	12	5	
<b>total</b>	<b>25</b>	<b>14464</b>	<b>15557</b>	<b>16255</b>	<b>11375</b>	<b>3774</b>	<b>10860</b>	<b>29887</b>	<b>10649</b>	<b>6769</b>	<b>14558</b>	<b>6937</b>	<b>4459</b>

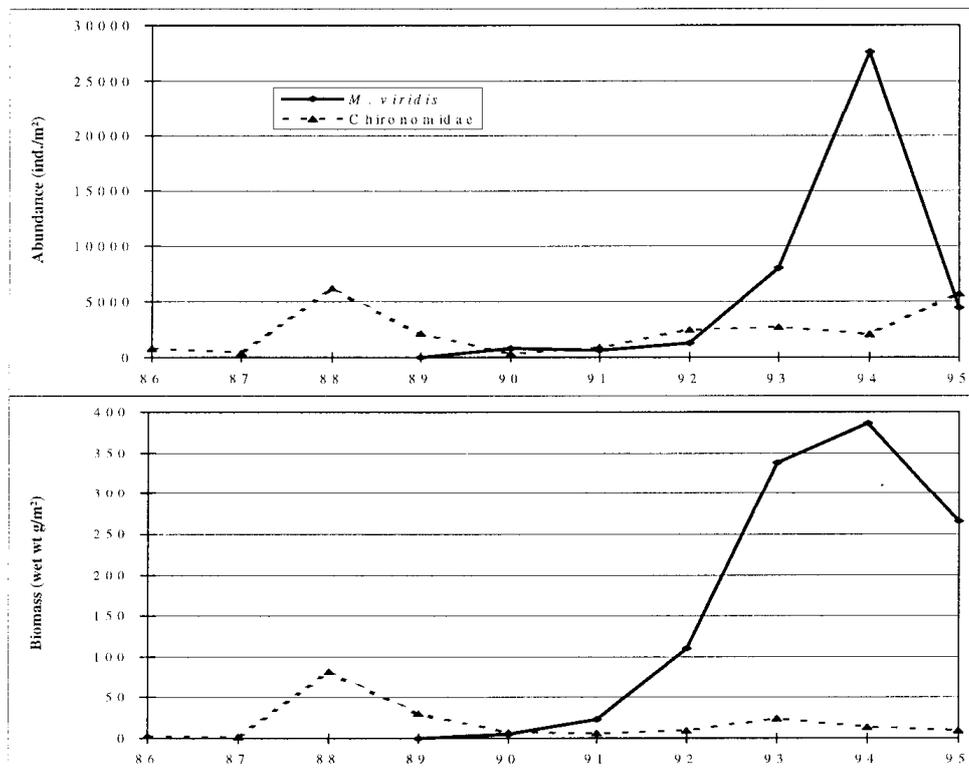


Figure 5. Macrozoobenthos abundances and biomasses in the Darss-Zingst bodden chain at stn. 2 from 1986 to 1995 (September).

Station 2 is situated inside the bodden chain and has a much lower salinity. *M. viridis* colonized this station 1 or 2 years later than station 1 (Fig. 5). The chironomids (*Chironomus plumosus* and *Ch. halophilus* types) were the dominant faunistic elements before the arrival of the spionid and achieved mean densities of 200–2,000 ind./m<sup>2</sup> (max.: 6,200 ind./m<sup>2</sup>) and biomasses of 3–10 g/m<sup>2</sup> (max.:

80 g/m<sup>2</sup>). Chironomid abundance has not decreased since *M. viridis* arrived at the station. The spionid has proliferated since 1990 and had a mean abundance of around 25,000 ind./m<sup>2</sup> and biomasses of between 350 and 400 g/m<sup>2</sup> in 1994. In 1995 the abundance of *M. viridis* decreased owing to poor reproductive performance due to low salinities of around 2 ‰ in autumn 1994 (Fig. 9).

Fig. 6 shows the variations in abundance at Station 2 during the past 4 years. Abundances increased until 1994, reaching a maximum density of 60,000 ind./m<sup>2</sup> in February of that year, and then decrease from mid-1994 onwards. The mean density observed in 1995 was 4,000 ind./m<sup>2</sup>.

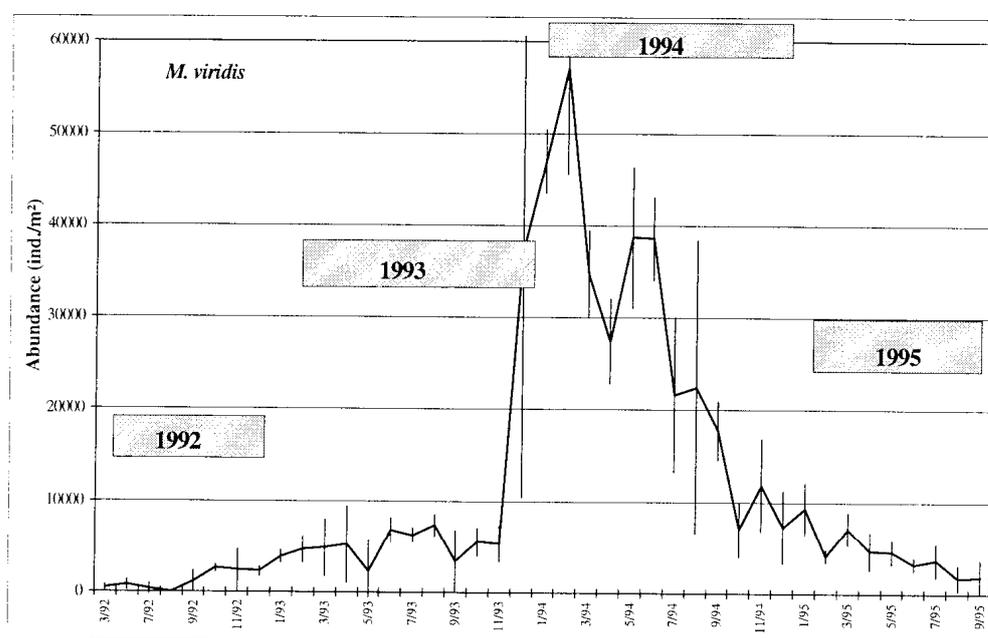


Figure 6. Abundances of *M. viridis* in the Darss-Zingst bodden chain at stn. 2 from March 1992 to September 1995 (means of 3 samples per month with standard deviation).

*M. viridis* has achieved a relative abundance of 50 % in terms of individuals and 90 % in terms of biomass at this station during the past 4 years (Fig. 7). Altogether 12 taxa were found here (Tab. 1).

The development of generations of *M. viridis* at stn. 2 shown in Fig. 8. The spionid polychaete has a life span of at least 3 years. As a rule, three generations coexist as any one time. Four generations (F1 to F4) were distinguished during our studies.

The key to the varying success of reproduction in the past four years is to be found in the salinity range during this period (Fig. 9). The larvae of *M. viridis* can not develop at salinities below 5 ‰. No new generations were produced at stations where the salinity was lower than 5 ‰. Reproduction was restricted to areas with higher salinities.

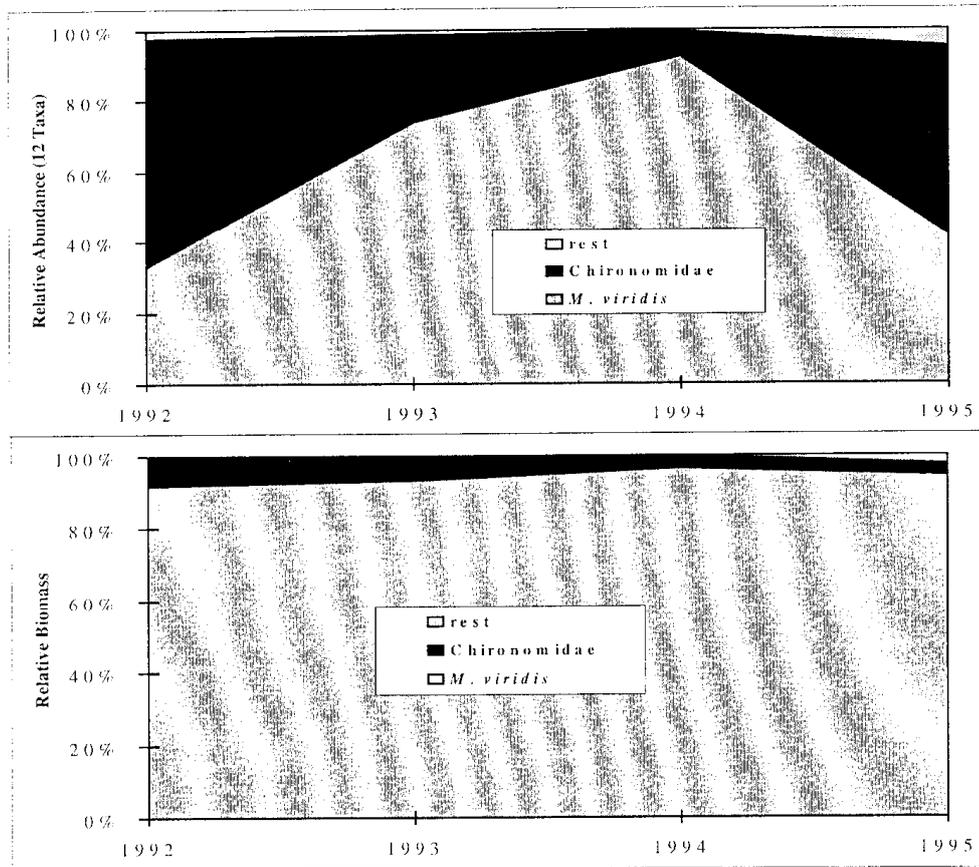


Figure 7. Relative abundances and biomasses (in %) within the macrozoobenthos in the Darss-Zingst boddenchain at stn. 2 from 1992 to 1995.

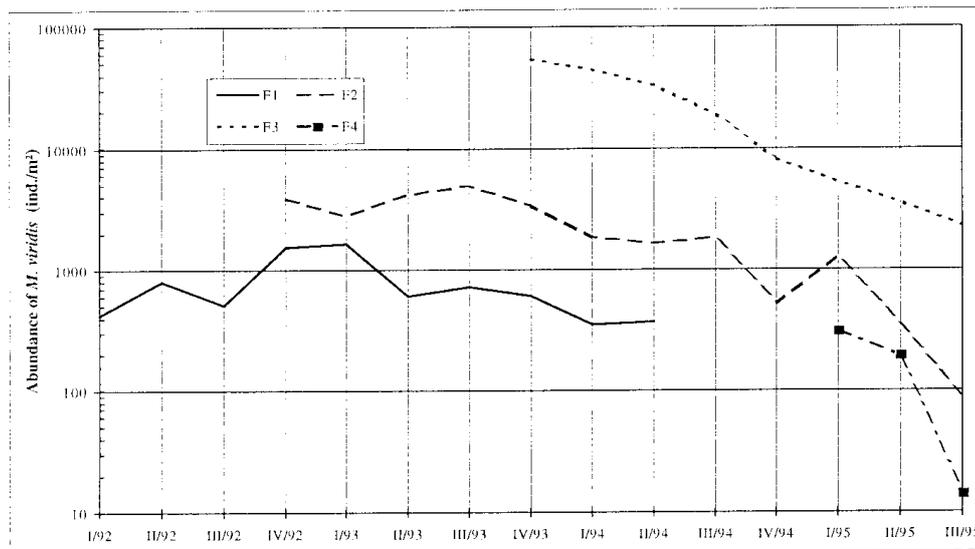


Figure 8. Generations of *M. viridis* in the Darss-Zingst boddenchain at stn. 2 from 1992 to 1995 (representation in quarters = means of 3 months and standard deviation).

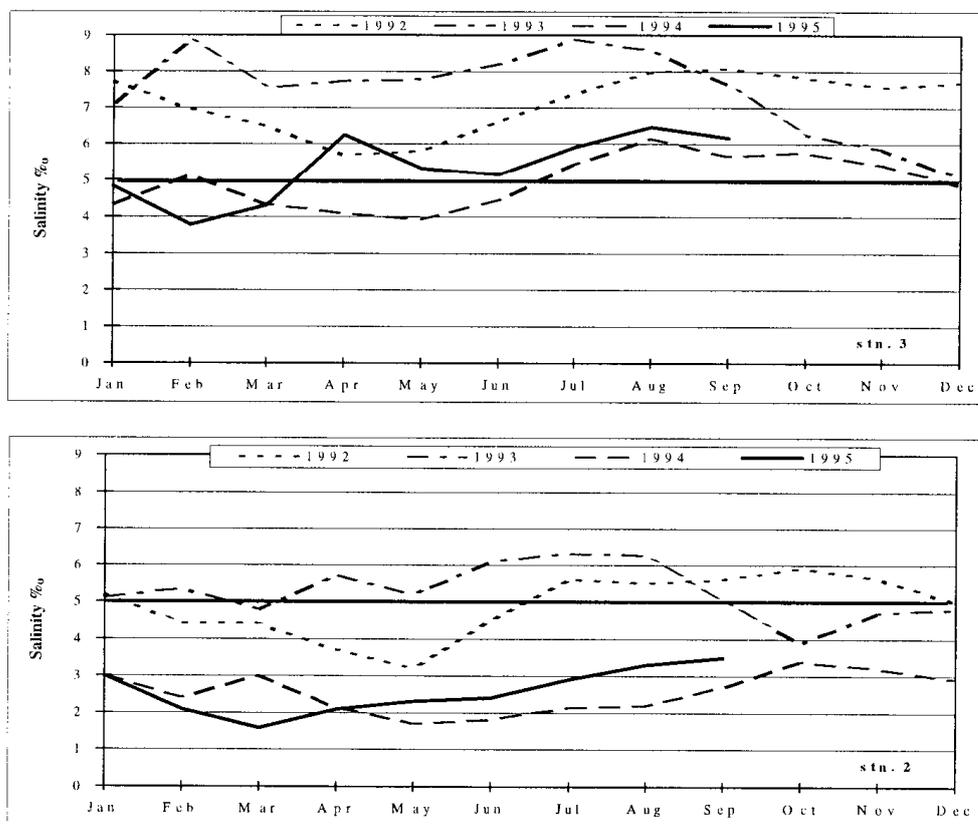


Figure 9. Range of salinity in ‰ in the Darss-Zingst bodden chain at stns. 2 and 3 from 1992 to 1995 (5 ‰-boundaries as thicker lines).

This is also reflected in the size-frequency distribution of *M. viridis* at stn. 2 based on the greatest width in mm between the 5th and 10th setigers (Fig. 10). In 1992 and 1993 *M. viridis* successfully reproduced and settled at this station. In 1994, however, there was no apparent reproduction, only a few isolated specimens being found at the beginning of 1995, and these were probably immigrants from more saline areas.

Also, growth was more rapid in the F2 generation from 1992 to 93 in the F2 (0.8 mm) than in the F3 generation from 1993 to 94 (0.4 mm). This was probably due to the higher abundance (6,000 in 1992/93 compared with 60,000 in 1993/94) and the corresponding increase in intraspecific feeding competition after settlement in autumn of 1993.

The size-frequency distribution at stn. 3 (Fig. 11) shows that reproduction takes place normally at salinities of around 5 ‰ and above. Successful reproduction and settlement were observed every year during our studies at this station.

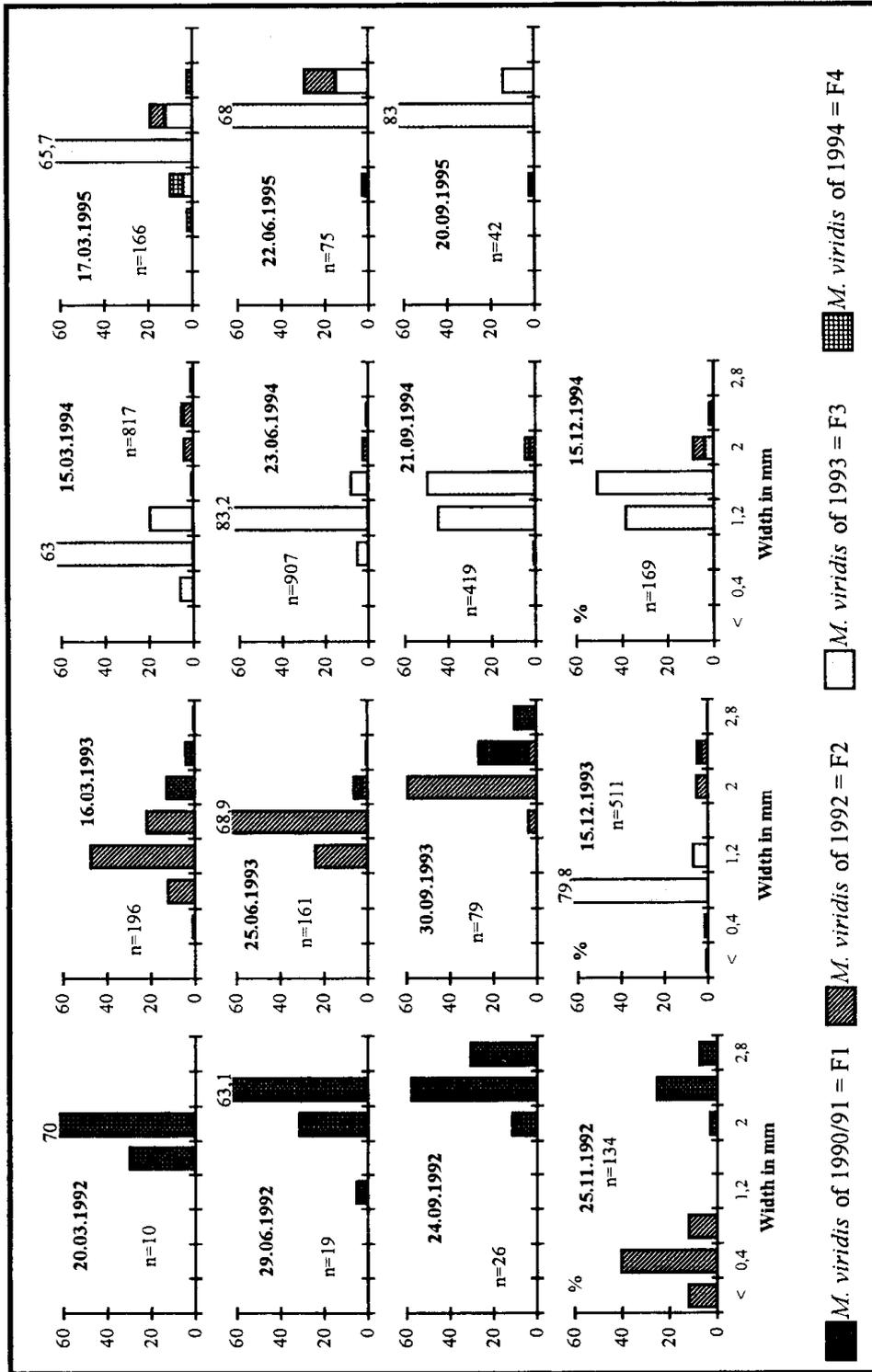


Figure 10. Size-frequency distribution of *M. viridis* at stn. 2 based on the greatest width in mm between 5th and 10th setiger from 1992 to 1995.

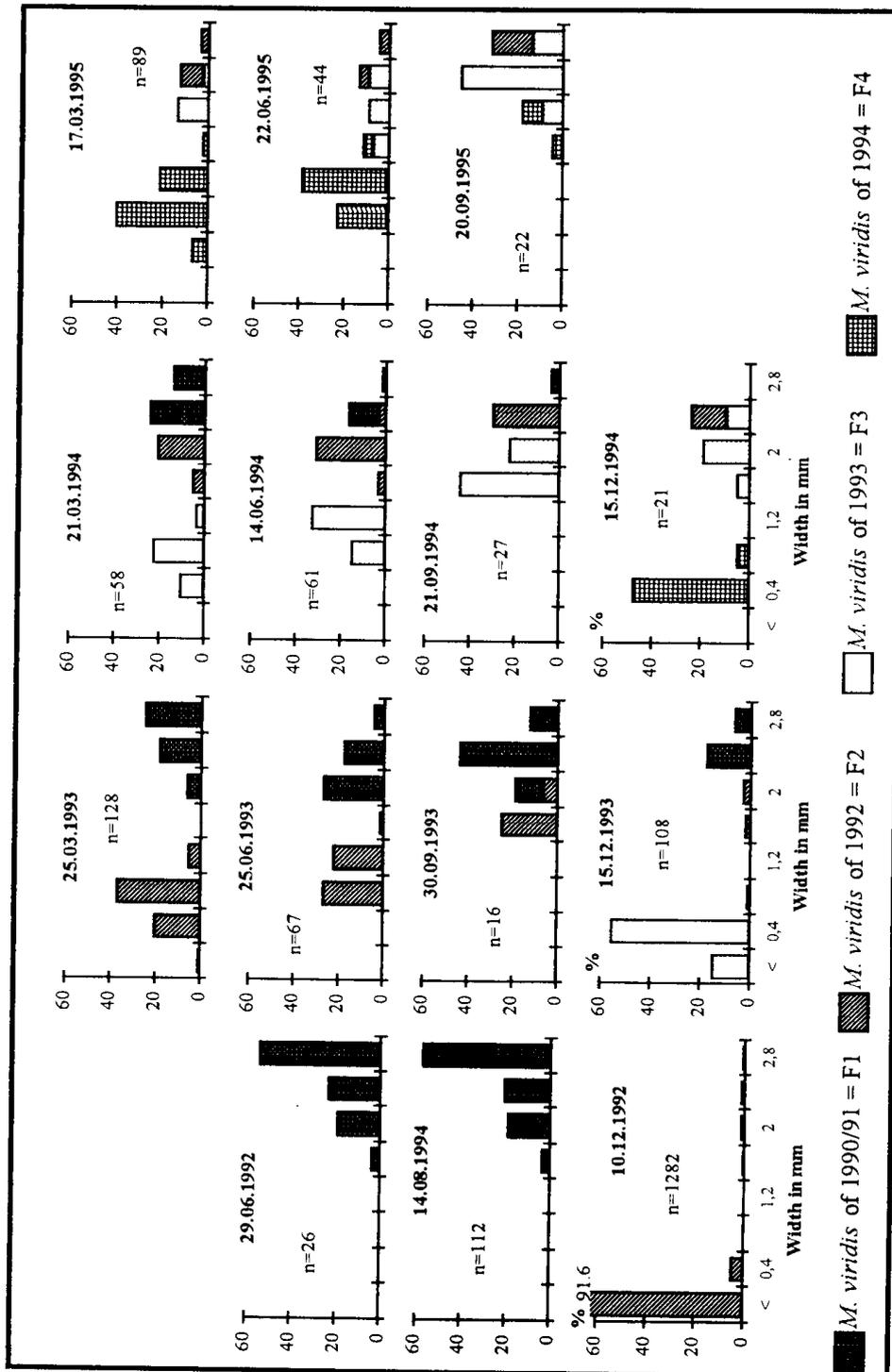


Figure 11. Size-frequency distribution of *M. viridis* at stn. 3 based on the greatest width in mm between 5th and 10th setiger from 1992 to 1995.

Fig. 12 presents the interactions and relationships between *M. viridis* and other indigenous macrozoobenthos representatives. Significant negative correlations were observed between adult *M. viridis* and both the naidids (*Paranais litoralis* and *Nais elinguis*) and the amphipod *Corophium volutator*. Significant positive interactions were found between adult and juvenile *M. viridis*.

The correlations found between juvenile *M. viridis* and the chironomids (*Ch. plumosus* and *Ch. halophilus* types) were significantly positive. The correlations between *H. diversicolor* and adult and juvenile *M. viridis* were different, but not significant.

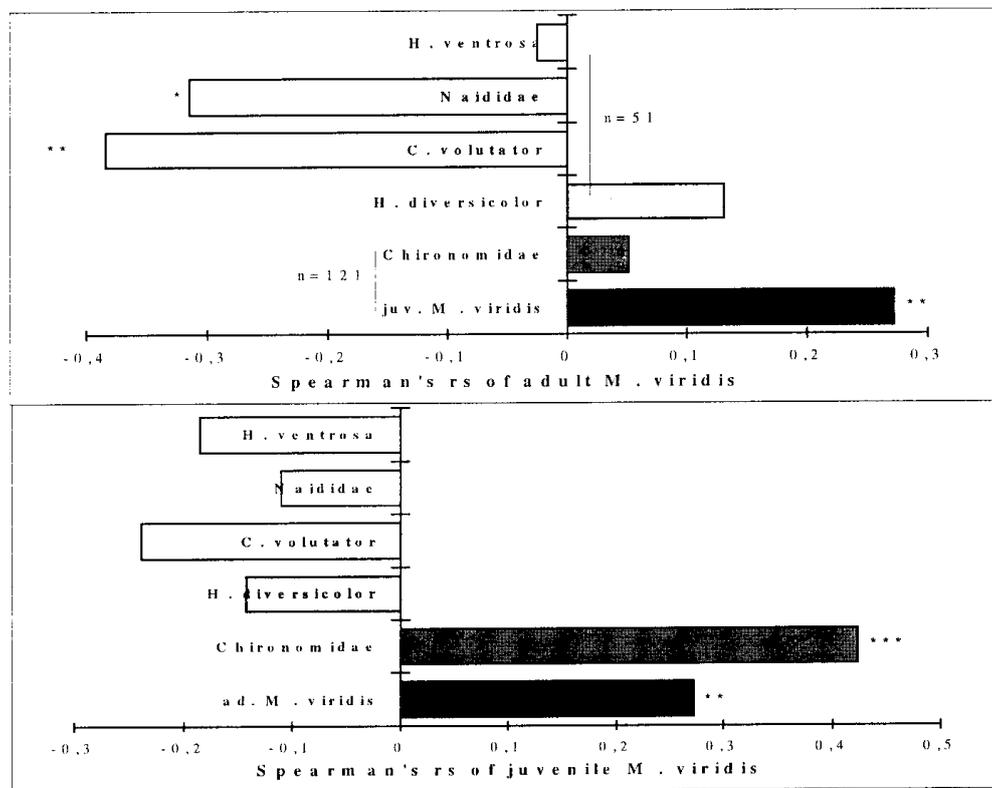


Figure 12. Spearman's rank correlation between adult/juvenile *M. viridis* and other taxa of the macrozoobenthos (\* $p=0.05$ ; \*\* $p=0.01$ ; \*\*\* $p=0.001$ ).

## Discussion

*M. viridis* has spread rapidly since it was first found in the bodden chain and is now one of the predominant faunistic elements. The dramatic increase in its abundance and biomass seemed bound to have some impact on the indigenous macrozoobenthos. However, comparison of our results with data published in the literature reveals no negative influence. On the contrary, the spionid even seems to facilitate colonization of the substrate by other organisms. Sarda (personal

communication) reported similar results, calling the *M. viridis* found during his studies in North America cold-tolerant opportunists. In contrast to the significant negative correlations found between *M. viridis* and *H. diversicolor* by Atkins et al. (1987), nereid abundances and biomasses do not seem to have declined in the bodden chain. Essink and Kleef (1993) and Saavedra-Perez (1990) also noted that abundances of *H. diversicolor* decreased after the spionid had appeared, but the reductions were not significant. Unfortunately, these authors did not study adult and juvenile animals separately in this respect. Kolbe (1993) found no negative correlation in the Weser estuary (Germany). Competition and predation studies (Röhrig, 1995, Zettler, unpubl.) have shown that adult *M. viridis* (>200 setigers) and adult *H. diversicolor* (>80 segments) do not influence each other negatively. Although a negative correlation between adult *H. diversicolor* seems likely, the values we obtained did not yield a significant correlation.

The reason for the significant negative correlation between juvenile *M. viridis* and *C. volutator* is unclear. Adult *M. viridis* also correlated negatively with this amphipod. The tentacular motions and burrowing activity of the spionid possibly create sufficient disturbance to induce *C. volutator* to emigrate. This negative effect has also been observed in both laboratory and field studies (Zettler 1995a, Zettler unpubl.). Röhrig (1995) has also reported similar results in the bodden chain. In the North Sea, in contrast, Essink and Kleef (1993) found significant positive correlations between *M. viridis* and *C. volutator*.

What might be the factor encouraging some organisms to settle while inhibiting others? *M. viridis* builds L-shaped, vertical and non-ramified burrows extending down to a depth of about 35 cm (Zettler et al. 1994). The effect of these bioturbate activities might be to prepare the sediment or make it more attractive for other organisms (as proposed by Gallagher et al. 1983). On the other hand, other organisms that are less tolerant to bioturbation would avoid the area. Possible reasons for the facilitatory and inhibitory effects of *M. viridis* are presented in Fig. 13.

The fluctuations in the abundance of *M. viridis* are very closely linked to reproductive success. Successful reproduction takes place only in regions with salinities higher than 5 ‰ since the planktic larvae need such salinities to develop (Bochert and Bick 1995). Owing to its mobility, however, the spionid is able, both as larvae and adults, to reach other areas with lower salinities either actively or by riding currents. The relatively long life span of about 3 years allows it to survive periods of low reproduction in such areas. This explains how *M. viridis* has successfully established in areas of the bodden chain with salinities between 0.5 and 10 ‰. Also able to survive exposure of the sediment to the air and even ice without difficulty, the species is perfectly adapted to the varying abiotic factors in the bodden chain (see also Zettler 1995a).

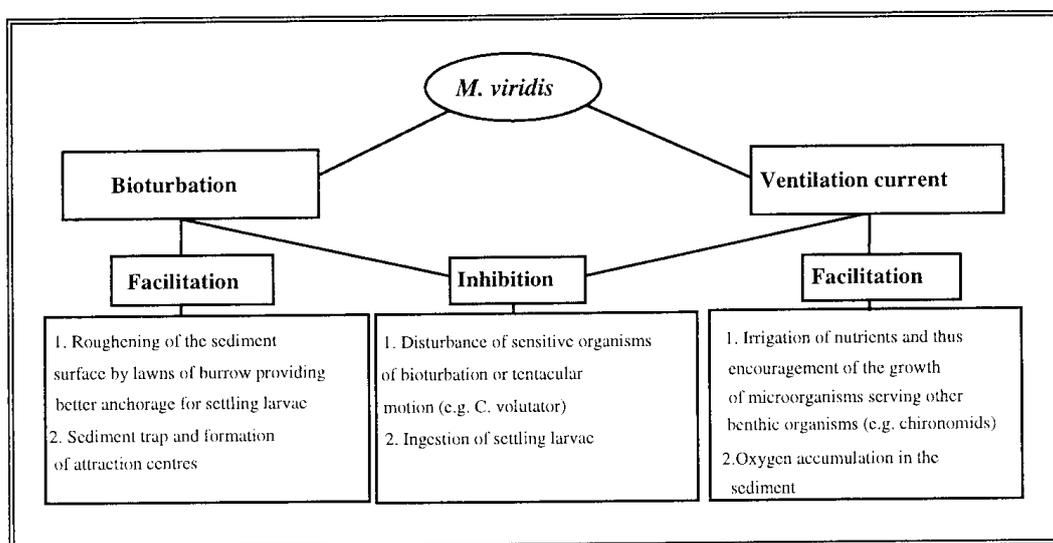


Figure 13. Possible reasons for the facilitatory and inhibitory effects of *M. viridis*.

And why was the immigration of *M. viridis* into the coastal waters of the Baltic so successful? The Baltic Sea is relatively young. Since the composition of indigenous species was drastically impoverished by the last glaciation, it has been a scene of constant new colonization and succession (Leppäkoski 1984, 1991). The gaps in the Baltic communities have obviously left plenty of room for immigrants. However, we must wait and see if the new species can hold their own and find a suitable niche for the longer term ("The role of an organism within a community" Krebs (1994) p.245).

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### References

- Arndt, E. A. 1988 Zusammenfassende Ergebnisse von Untersuchungen am Makrozoobenthos der Darß-Zingster Boddenkette von 1969–1987. Wissenschaftliche Zeitschrift der WPU Rostock, N-Reihe 37: 6–12.
- Arndt, E. A. 1989. Ecological, physiological and historical aspects of brackish water fauna distribution. *In* Reproduction, Genetics and Distribution of Marine Organisms, Ed. by J. S. Ryland and P. A. Tyler. Olsen & Olsen, Fredensborg. pp. 327–338.
- Arndt, E. A. 1994. Struktur und Entwicklung des Makrozoobenthos in der Darß-Zingster Boddenkette im Laufe der letzten 25 Jahre unter besonderer Berücksichtigung der Makrozoobenthos-Entwicklung im Saaler Bodden von 1986–1990. Rostocker Meeresbiologische Beiträge, 2: 93–120.

- Atkins, S. M.; Jones, A. M.; Garwood, P. R. 1987. The ecology and reproductive cycle of a population of *Marenzelleria viridis* (Annelida: Polychaeta: Spionidae) in the Tay Estuary. *Proceedings of the Royal Society of Edinburgh*, 92B: 311–322.
- Bick, A. and Burckhardt, R. 1989. Erstnachweis von *Marenzelleria viridis* (Polychaeta, Spionidae) für den Ostseeraum, mit einem Bestimmungsschlüssel der Spioniden der Ostsee. *Mitteilungen des Zoologischen Museums Berlin*, 65: 237–247.
- Bochert, R. and Bick, A. 1995. Der Einfluß von Salzgehalt und Temperatur auf die Larvalentwicklung von *Marenzelleria viridis* (Polychaeta: Spionidae). *Verhandlungen der Deutschen Zoologischen Gesellschaft*, 88.1: p21.
- Essink, K. and Kleef, H. L. 1993. Distribution and life cycle of the North American spionid polychaete *Marenzelleria viridis* (Verrill, 1873) in the Ems Estuary. *Netherlands Journal of Aquatic Ecology*, 27: 237–246.
- Gallagher, E.; Jumars, P. A.; Trueblood, D. D. 1983. Facilitation of soft-bottom benthic succession by tube builders. *Ecology*, 64: 1200–1216.
- Gruszka, P. 1991. *Marenzelleria viridis* (Verrill, 1873) (Polychaeta: Spionidae) – a new component of shallow water benthic community in the southern Baltic. *Acta Ichthyologica et Piscatoria, Suppl. XXI*: 57–65.
- Günther, B.; Andres, D.; Ossig, S. 1995. Status-Quo-Erfassung des Makrozoobenthos im Peenestrom und im Kleinen Haff. *Rostocker Meeresbiologische Beiträge*, 3: 189–219.
- Jansson, K. 1994. Alien species in the marine environment. Introduction to the Baltic Sea and the Swedish west coast. Swedish Environmental Protection Agency, Report 4357: pp. 68.
- Kolbe, K. 1993. Die Wesermündung als Lebensraum von *Marenzelleria viridis*. Statusseminar zum BMFT-Verbundprojekt, Warnemünde
- Krebs, C. J. 1994. *Ecology. The Experimental Analysis of Distribution and Abundance*. Harper Collins College Publishers, New York. 801 pp.
- Lagzdins, G. and Pallo, P. 1994. *Marenzelleria viridis* (Verrill) (Polychaeta, Spionidae) – A new species for the Gulf of Riga. *Proceedings of the Estonian Academy of Science*, 43: 184–188.
- Leppäkoski, E. 1984. Introduced species in the Baltic Sea and its coastal ecosystems. *Ophelia, Suppl. 3*: 123–135.
- Leppäkoski, E. 1991. Introduced species – resource or threat in brackish-water Seas? Exemples from the Baltic and the Black Sea. *Marine Pollution Bulletin*, 23: 219–223.
- Möller, R., 1984: Verbreitungsökologische Untersuchungen am Makrozoobenthos im Winterhalbjahr 1983/84 im Barther Bodden. Diplom Universität Rostock, pp. 80.
- Norkko, A.; Bonsdorff, E.; Boström, C. 1993. Observations of the polychaete *Marenzelleria viridis* (Verrill) on a shallow sandy bottom on the South coast of Finland. *Memoranda Soc. Fauna Flora Fennica*, 69: 112–113.
- Olenin, S. and Chubarova, S. 1992. Recent introduction of the North American spionid polychaete *Marenzelleria viridis* (Verrill, 1873) in the coastal areas of the southeastern part of the Baltic area. *International Symposium about Function of Coastal Ecosystems in Various Geographical Regions*, Gdansk University, p. 20.
- Persson, L. E. 1994. Nya arter ändrar Östersjön mer än vara föreningar. *Fauna och Flora*, 5: 33–37.
- Röhrig, A. 1995. Aspekte zur Sedimentpräferenz von *Marenzelleria viridis* (Verrill 1873) (Polychaeta; Spionidae) sowie Interaktionen zwischen *M. viridis* und der autochthonen Fauna eines inneren Küstengewässers der südlichen Ostsee. Diplom Universität Hannover, pp. 70.
- Rudolph, K. 1994. Erstnachweis des Amphipoden *Gammarus tigrinus* Sexton, 1939 (Crustacea: Gammaridea) im Peenestrom und Achterwasser (südliche Ostseeküste). *Naturschutzarbeit in Mecklenburg-Vorpommern*, 37(2): 23–29
- Saavedra-Perez, M. 1990. Bonitoring des Makrozoobenthos im Greifswalder Bodden. Diplom Universität Rostock, pp. 99.

- Thiel, R. 1990. Untersuchungen zur Ökologie der Jung- und Kleinfischgemeinschaften in einem Boddengewässer der südlichen Ostsee. Dissertation Universität Rostock, pp. 120.
- Zettler, M. L. 1993. Untersuchungen zur Biologie und Ökologie von *Marenzelleria viridis* (Polychaeta: Spionidae) in der Darß-Zingster Boddenkette. Diplom Universität Rostock, pp. 80.
- Zettler, M. L. 1994. Immigration und Ausbreitung eines nordamerikanischen Polychaeten in ein inneres Küstengewässer der südlichen Ostsee und Auswirkungen auf das autochthone Makrozoobenthos. Erw. Zusammenfassung Jahrestagung Deutsche Gesellschaft für Limnologie, Hamburg, Bd. 2: 695–699.
- Zettler, M. L. 1995a. Untersuchung zur Verteilung des Makrozoobenthos in einem Küstengewässer der südlichen Ostsee in Abhängigkeit von abiotischen Faktoren. Rostocker Meeresbiologische Beiträge, 3: 171–188.
- Zettler, M. L. 1995b. Erstnachweis von *Gammarus tigrinus* Sexton, 1939 (Crustacea: Amphipoda) in der Darß-Zingster-Boddenkette und seine derzeitige Verbreitung an der deutschen Ostseeküste. Archiv der Freunde der Naturgeschichte in Mecklenburg, 34: 137–140.
- Zettler, M. L. 1996. Successful establishment of the spionid polychaete, *Marenzelleria viridis* (Verrill 1873), in the Darss-Zingst estuary (southern Baltic) and its influence on the indigenous macrozoobenthos. Archive of Fishery and Marine Research, 43: 273–284.
- Zettler, M. L.; Bochert, R.; Bick, A. 1994. Röhrenbau und Vertikalverteilung von *Marenzelleria viridis* (Polychaeta: Spionidae) in einem inneren Küstengewässer der südlichen Ostsee. Rostocker Meeresbiologische Beiträge, 2: 215–225.
- Zettler, M. L.; Bick, A.; Bochert, R. 1995. Distribution and population dynamics of *Marenzelleria viridis* (Polychaeta: Spionidae) in a coastal water of the southern Baltic. Archive of Fishery and Marine Research, 42: 209–224.
- Zettler, M. L. and Bick, A. 1996. The analysis of small- and mesoscale dispersion patterns of *Marenzelleria viridis* (Polychaeta: Spionidae) in a coastal water of the southern Baltic. Helgoländer Meeresuntersuchungen, 50: 265–286.
- Zmudzinsky, L.; Chubarova, S.; Dobrowolski, Z.; Gruszka, P.; Fall, I.; Olenin, S.; Wolnomiejski, N. 1993. Expansion of the spionid polychaete *Marenzelleria viridis* in the south-eastern part of the Baltic Sea. Proceedings of the 13th BMB-Symposium, Riga, Latvia (in press).