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ANNUAL DYNAMICS OF ABUNDANCE, BIOMASS AND SURVIVAL OF MEROPLANKTON IN SEVASTOPOL BAY, BLACK SEA

The first comprehensive data on species composition, abundance, biomass and survival (living/dead ratio) of meroplankton in Sevastopol Bay (Black Sea) are presented. Marked differences were observed between the years 1998 and 1999, and these could be attributed to the hydrology and the eutrophication status of the different parts of the Bay. Shannon index and selected community parameters (number of species, biomass, numbers of individuals) indicated that South Bay was the worst affected part of the Bay with the greatest eutrophication impact on the meroplankton. The early larval stages of the barnacle *Balanus improvisus* and of the polychaete *Polydora* sp. were the most sensitive to presumed environmental stresses. It is suggested that the mortality of certain ontogenetic stages of the meroplankton can be used as sensitive indicators of ecosystem health with good spatial discrimination. The canonical correlations between biological and environmental variables ranged from 86 – 87 %. Discriminant functions defined two well-defined subecosystems in the Bay. Long-term comparison with 1989/90 data for the Bay outlet showed that molluscan larval mortality had remained unchanged, while that of Polychaete and Cirripedia had more than doubled, suggesting that they could be sensitive to increased eutrophication in Sevastopol Bay.

Keywords: abundance, biomass, survival, meroplankton, environmental conditions, Sevastopol Bay, Black Sea (Ukraine)

Sevastopol Bay is industrialized and urbanized, typical of many other bays in the world and the greatly indented coastline favours the isolation of parts from the renewal effects of the sea or fresh water exchanges. In 1977, the entrance to Sevastopol Bay was further restricted by construction of a jetty. Concomitant changes in freshwater inflow and increases in sewage discharge have resulted in an escalating anthropogenic impact on Sevastopol Bay such that there has been a marked and consistent decline in quality status over the last 25 years [14, 19, 32, 40].

Sevastopol Bay was one of the first focuses of work on taxonomy and morphology of pelagic larvae in coastal regions and bays of the Black Sea [9, 17, 49]. Later work, after the construction of the jetty, added information on abundance and survival of the meroplankton in and around the Bay [26, 34, 38]. Some of this information was recently brought together in an evaluation of eutrophication status of Sevastopol Bay [13]. However, data on overall meroplankton abundance rather than on individual taxa are still very scanty and relate rather to the neighbouring area of Sevastopol roadstead than Sevastopol Bay itself [24, 27]. Of the studies on the quantitative distribution of larvae in the wider Black Sea coastal waters and bays, the majority of them focus on Bivalvia [18, 25, 39], Polychaeta and Gastropoda [23, 28], and Cirripedia [3, 45].

Studies elsewhere on meroplankton have demonstrated the importance of seasonality and environmental variables on spatial structure and succession [5, 6] and long-term data sets are now underpinning investigations into climate change [12, 31]. However, the influence of biological factors is less studied, although some work does suggest that meroplankton are relatively inefficient feeders [15] and are in turn readily taken by most predators [7]. In the North Sea, there is some suggestion of top-down control by fisheries [41].

This study sets out the seasonal cycle of the population dynamics of the meroplankton with particular reference to the contamination status of the different compartments of Sevastopol Bay.

Materials and methods. Over many years of research [14] a carefully characterized set of sampling sites has evolved for the study of Sevastopol Bay. For the purposes of this current study, zooplankton collections were taken at three sites in different areas of Sevastopol Bay (Figure 1): at the entrance (site 7, depth 14 m), at the head of the Bay (site 2, depth 10 – 15 m) and in South Bay (site 6, depth 7 – 10 m) which, as has been previously shown, differ in the degree of anthropogenic contamination, water circulation and physical-chemical characteristics. These earlier studies established that South Bay (site 6) was the most polluted while the area at the bay inlet (site 7) was the least polluted [14, 35]. For comparison, plankton hauls were taken at a reference site outside Sevastopol Bay (site 9, depth 15 m).

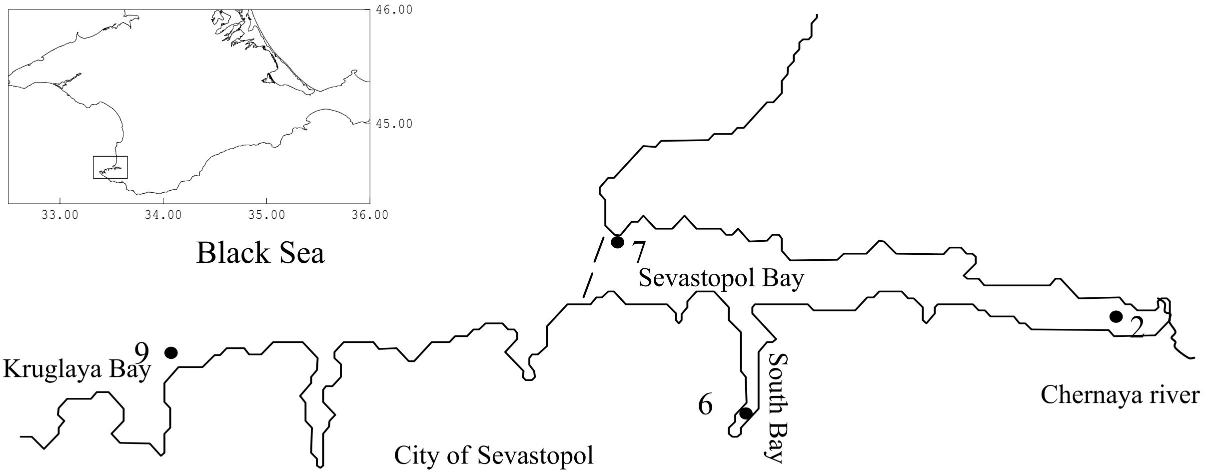

Fig. 1 Stations of meroplanktonic investigations in Sevastopol Bay 1998 – 1999
Рис. 1. Расположение станций исследования меропланктона в Севастопольской бухте в 1998 – 1999 гг.

From May 1998 to November 1999, single monthly (with the exception of March 1999 due to bad weather) vertical hauls from 0 – 10 m or from the bottom to the surface were taken with a plankton net (150 µm mesh, inlet diameter 36 cm). The collected plankton samples were immediately fixed on board during sampling by formalin bringing its concentration in the bottle to 4 %. After the lapse of 5 to 14 days of sampling, species identification, their abundance and differentiation the individuals into living and dead to estimate survival were carried on in the laboratory. The state of the chitin envelope, body transparency and turgor, the intactness of bristles and appendages and the presence of the distinctive coiled structures in the muscles during their decomposition were the criteria used to establish the viability of the individual. The visual evaluation was checked with the dye method of B. G. Alexandrov and O.A. Ablov [2], which has been shown to give similar results [34]. The number of living and dead (before fixation) organisms were determined for each species and for each size class. The abundance of cirripede and molluscan larvae and small polychaetes was estimated from replicate 3.0 ml sub-samples while that of large polychaetes and decapod larvae was estimated from the whole sample. The biomass of the organisms was calculated according to [37]. The general tendencies of the biomass' changes of larvae were evaluated. The biomass of the polychaetes and cirripedies were calculated by length in cube, where it was possible. Hydrophysical and hydrochemical data were obtained at the same time [32].

Canonical correlation, multiple regression and discriminant analysis were used to test the relationship between biological variables and environmental variables. Statistical analyses were performed according to [1, 11]. The variables were categorized into one of three groups: the 1st group comprised the biological variables of living biomass and the relative percentages of living and dead cirripede, polychaete and mollusk larvae, the 2nd group had the hydrophysical variables of temperature and salinity; and the 3rd group had the hydrochemical variables O_2, PO_4^{2-}, SiO_3^{2-}, NO_3^-, NO_2^- and NH_4^+ concentrations.

Results. Over the period 1998 - 1999, 40 species, representing 32 families of pelagic larvae of the benthic invertebrates were found in Sevastopol Bay (Table 1).

Table 1 Taxonomic composition and maximal abundance (individuals·m^{-3}) of meroplankton in Sevastopol Bay 1998 – 1999 at sites 2, 6 and 7 (see Fig. 1 for locations)

Табл. 1 Таксономический состав и максимальная численность (экз. $м^{-3}$) меропланктона в Севастопольской бухте 1998 – 1999 гг. на ст. 2, 6 и 7 (расположение станций – на рис. 1)

Class, order, family, species	Site 7	Site 2	Site 6
1	2	3	4
POLYCHAETA			
Spionidae			
Polydora sp.	490	1178	807
Microspio meznikowianus (Claparede, 1869*)*	60	20	21
Prionospio cirrifera Wirren, 1883	2		
Nerine cirratulus (Della Chaije, 1827)	4	7	10
Nereidae			
Neanthes succinea Leuckart, 1847	96	30	72
Nereis zonata Malmgren, 1867	4		
Nephthydidae			
Nephthys hombergii Aud. Et M.-Edwards, 1834	4		
Sigalionidae			
Pholoe synophthalmica Claparede, 1868	6		
Polynoidae			
Harmothoe reticulata Claparede, 1870	12	10	1
BIVALVIA			
Mytilidae			
Mytilus galloprovincialis Lamarck, 1819	783	1353	371
Mytilaster lineatus (Gmelin, 1790)	72	76	40
Veneridae			
Polititapes aurea (Gmelin, 1790*)*	4	24	103
Teredenidae			
Teredo navalis Linne, 1758	16	1	30
Tellinidae			
Scapharca inaequivalvis (Bruguiere*,* 1789)	32	12	5
GASTROPODA			
Bittiidae			
Bittium reticulatum (Costa, 1799**)**	50	520	180
Rissoidae			
Rissoa parva (Costa, 1779*)*	22	55	200
R. membranacea Adams, 1797	30	75	52

Table 1 (Contd)

1	2	3	4
Caecidae			
Caecum elegans Perejaslavtseva, 1891	288	80	432
Hydrobiidae			
Hydrobia acuta (Draparnaud, 1805)	2	5	192
Muricidae			
Rapana thomasiana Grosse, 1861	1	2	2
Turbonillidae			
Parthenina terebellum (Philippi, 1844)	34	12	200
Limapontiidae			
Limapontia capitata (Mueller, (1773)	28	18	220
Retusidae			
Retusa truncatella (Locard, 1892)	4	2	2
Haminoeidae			
Haminoea navicula (Costa, 1778)	16	13	16
Tergipedidae			
Tergipes tergipes (Forskal, 1775)	4	1	24
CRUSTACEA DECAPODA			
Calianassidae			
Upogebia pusilla (Petagna, 1792)	64	15	48
Xanthidae			
Xantho poressa (Olivi, 1792)	1	2	1
Rhithropanopeus harrisi tridentata (Maithland,1874)	8	7	6
Porcellanidae			
Pisidia longimana (Risso, 1815)	11	1	
Crangonidae			
Crangon crangon Linne, 1758	1		6
Palaemonidae			
Palaemon elegans Rathke, 1837	2	3	
Alpheidae			
Athanas nitescens Leach, 1814	2	4	
Alpheus dentipes Guerin, 1832	1		
Paguridae			
Diogenes pugilator Roux, 1828	4	8	3
Grapsidae			
Pachygrapsus marmoratus (Fabricius, 1793)	1		
Majidae.			
Macropodia sp.	1	4	2
CRUSTACEA CIRRIPEDIA,			
Balanidae			
Balanus improvisus Darwin, 1854	1993	5992	2787
Verrucidae			
Verruca splengeri Darwin, 1854	38		160
Phoronidea			
Phoronidae			
Phoronis euxenicola Selys-Long., 1907	6	2	
Ascidiacea			
Botryllidae			
Botryllus schlosseri (Pallas, 1766)	1		4
Total number of species (families)	**40 (32)**	**31 (26)**	**30 (25)**

The bulk of the larvae were polychaetes (10 species in 5 families), bivalves (5 species in 4 families), gastropods (11 species in 10 families) and decapods (11 species in 9 families) with only two species (in 2 different families) of cirripedes. Among the rarities were the actinotroch (class Phoronidea) *Phoronis euxinicola*, the only species found in the Black Sea, as well as ascidian *Botryllus schlosseri.* The highest number of taxa (40 species, 32 families) was found at the bay entrance (site 7) followed by the top part of Sevastopol Bay (site 2; 31 species, 26 families) and the South Bay (site 6; 30 species, 25 families). Larvae of *Balanus improvisus* and *Polydora* sp. were abundant in the meroplankton of all the three regions as were those of *Mytilus galloprovincialis,* with the greatest abundance of all three species at site 2 at the head of the Bay. High abundances of *Caecum elegans* and *Upogebia pusilla* larvae over the summer period were typical for South Bay. *Nephthys hombergii* and *Pholoe synophtalmica* larvae were rare and recorded only at site 7. At the same site there was a relatively rich decapod fauna of Alpheidae, Paguridae, and Grapsidae, among them *Pachygrapsus marmoratus* is listed in the Red Book of the Ukraine [22].

Figure 2 shows the annual cycle of diversity (number of species) and abundance (living individuals·m^{-3}) in the different regions of Sevastopol Bay. For both measures 1999 seemed to be a more successful year with higher peaks sustained into the autumn months.

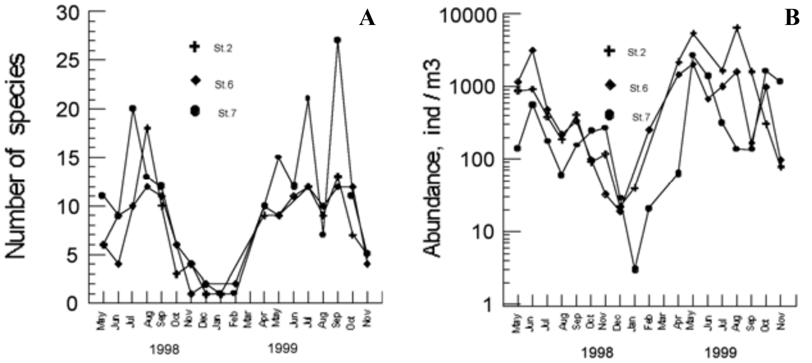

Fig. 2. Meroplankton in Sevastopol Bay 1998 – 1999 at sites 2, 6 and 7: number of species (A) and abundance of individuals·m^{-3} (B)
Рис. 2 Число видов (A) и численность, экз. м$^{-3}$ (B) в меропланктоне Севастопольской бухты (1998 - 1999 гг., станции 2, 6 и 7)

The Shannon index (H′, Fig. 3) follows a similar pattern to numbers of species (Fig. 2) but evenness ($J = H'/H_{max}$) was relatively constant with the exception of November 1998, when both extremely low (site 7) and extremely high (sites 2, 6) values were seen. Then site 2 showed a very low evenness value, as well as a very low H′ in August 1999. However, in the same month, neither the numbers of species nor individual abundance at site 2 were greatly different from those at other sites. The variation appears to be temporal rather than spatial, in that August 1999 saw a marked decline in all three diversity measures (species' number, H′, J) compared to July and September 1999 while density of individuals showed much less of a fall (Figs 2, 3).

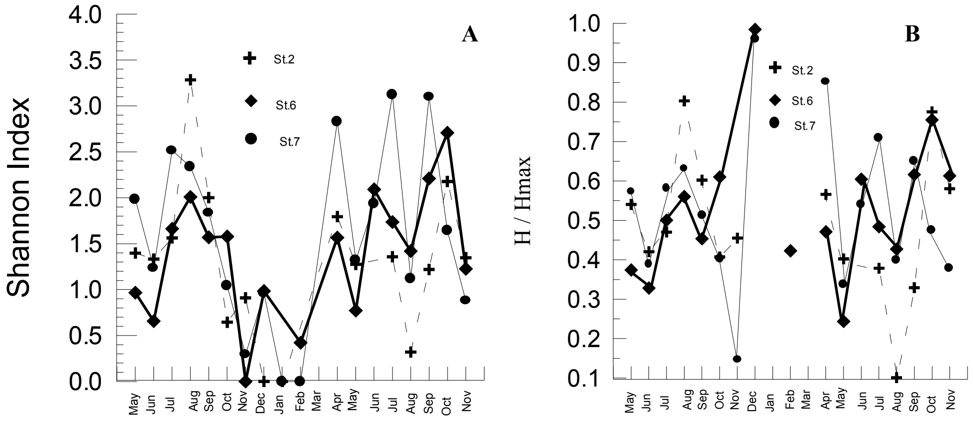

Fig. 3. Meroplankton in Sevastopol Bay 1998 – 1999 at sites 2, 6 and 7: Shannon indexH′, (A) and evenness $J = H'/H_{max}$, (B)
Рис 3. Меропланктон Севастопольской бухты в 1998 – 1999 гг.: индекс Шеннона H′, (A) и индекс равномерности распределения $J=H'/H_{max}$, (B)

The seasonal dynamics of the abundance of the dominant meroplankton taxa are given in Fig. 4 and they show clearly the greater numbers and bimodal peaks in 1999. The maximum density of cirripede larvae was recorded in June 1998, and again in May and in August 1999. These barnacle larvae were found throughout the year, but in extremely low numbers in January-February. In 1999, the highest density was recorded in the top part of the bay at site 2, whereas site 6 had the highest densities in 1998. Relatively low numbers of both polychaete and mollusk larvae were found in 1998 compared to the following year, when peak numbers were found at all sites, although with some variability in actual numbers and in the timings of the peaks (Fig. 4).

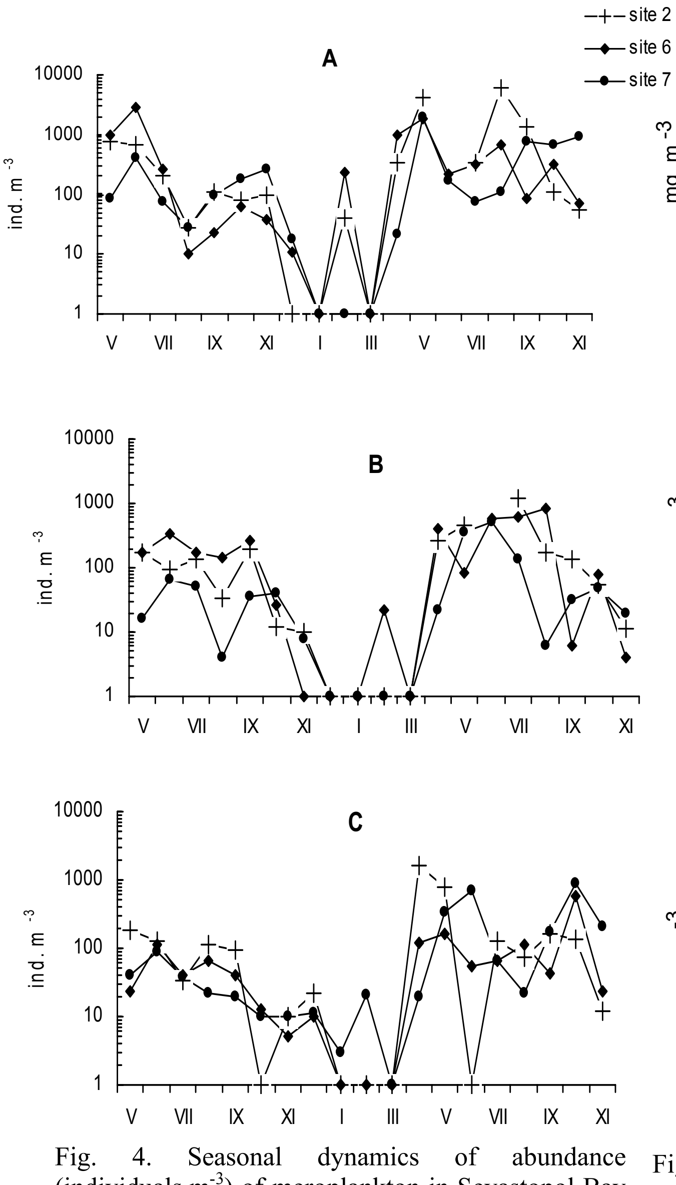

Fig. 4. Seasonal dynamics of abundance (individuals·m^{-3}) of meroplankton in Sevastopol Bay May (V) 1998 – December (XII) 1999 at sites 2, 6 and 7: A – Cirripedia, B – Polychaeta, C – Mollusca

Рис.4. Сезонная динамика численности (экз·м$^{-3}$) меропланктона в Севастопольской бухте за период май 1998 – декабрь 1999 гг. на станциях 2, 6 и 7: A – Cirripedia , B – Polychaeta, C –

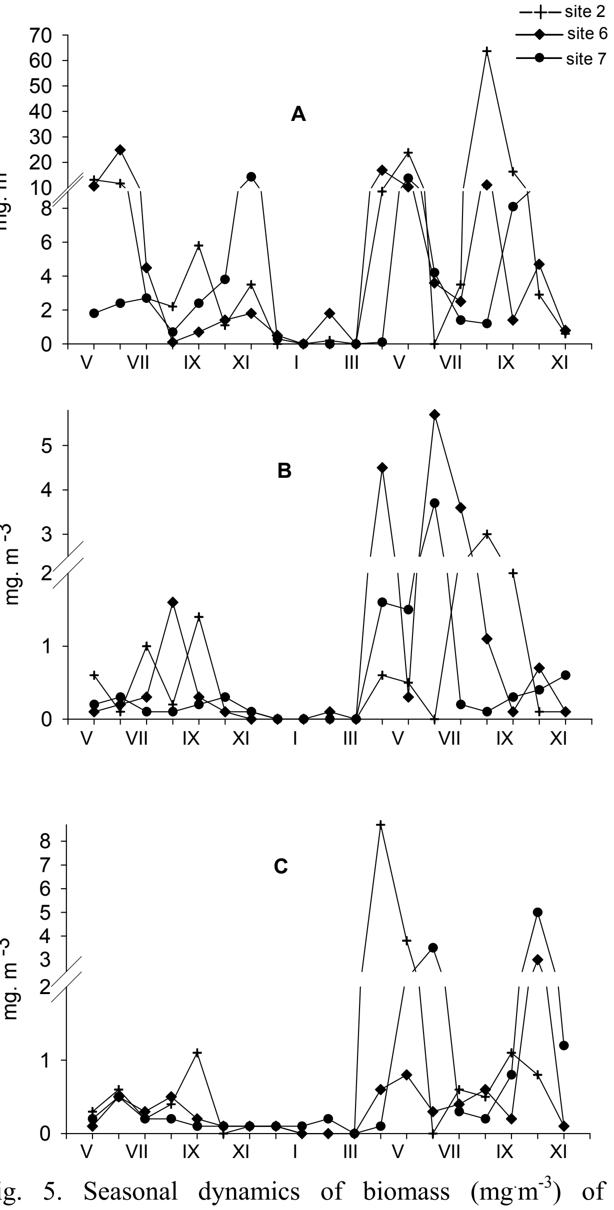

Fig. 5. Seasonal dynamics of biomass (mg·m^{-3}) of meroplankton in Sevastopol Bay May (V) 1998 – December (XII) 1999 at sites 2, 6 and 7: A – Cirripedia, B – Polychaeta, C – Mollusca

Рис.5. Сезонная динамика биомассы (мг·м$^{-3}$) меропланктона в Севастопольской Бухте за период с мая 1998 по декабрь 1999 г. на станциях 2, 6 и 7: A – Cirripedia, B – Polychaeta, C – Mollusca

Polychaete larvae were not found at all in the winter months from December to February, with the exception of one single individual (*Harmothoe* sp.) in February, while mollusk larvae peaked earliest in April 1999 at site 2. Decapod larvae were found only sporadically with little discernable pattern, and overall the highest numbers were found at site 2 at the top of the Bay.

A similar pattern, at least for the cirripedes and the mollusks, was seen in the seasonal cycle of biomass, but manifest differences were noted in the pattern of polychaete larval biomass (Fig. 5). The difference was marked in May-June, when polychaete larval abundance was dominated by the early developmental stages (Figs 4B and 5B). The high biomass of polychaete larvae at site 2 in August-September 1999 was the result of a predominance of large *Neanthes succinea* larvae, whereas in the South Bay (site 6), biomass was low in the same months despite relatively high abundance (Fig. 4B) because the small *Polydora* sp. larvae were dominant (Fig. 5B).

As shown in Table 2, survival, as indicated by the percent of dead individuals in the total meroplankton was low for years 1998 and 1999, and was lower than outside Sevastopol Bay - compare site 9 (17 – 18 % dead) with site 7 (35 – 39 %), site 2 (41 – 50 % dead) or site 6 (54 – 55 % dead). The lowest survival amongst the four meroplankton taxa at all the sites was recorded for Cirripedia and the region most subject to anthropogenic contamination (site 6) had the highest percent of dead individuals over all meroplankton groups (Table 2).

Table 2 Seasonal changes in meroplankton mortality (% of dead individuals) in the different regions of Sevastopol Bay: nd indicates no data; - indicates no specimens taken in hauls

Табл. 2 Сезонные изменения количества мертвых организмов (%) в различных районах Севастопольской бухты: nd – отсутствие данных, - отсутствие в ловах

Site/Group	1998						1999							
Month	V	VI	VII	VIII	IX	X	IV	V	VI	VII	VIII	IX	X	XI
Site 9														
Cirripedia	0	18	50	37	62	nd	-	0	40	27	nd	38	72	40
Polychaeta	4	0	32	0	14	nd	0	0	36	8	nd	-	10	-
Bivalvia	-	0	50	0	0	nd	0	0	24	30	nd	0	0	0
Gastropoda	-	0	50	0	0	nd	0	0	23	35	nd	0	0	0
All meroplankton	**2**	**10**	**33**	**13**	**29**		**0**	**0**	**35**	**27**		**35**	**72**	**37**
Site 7														
Cirripedia	44	21	53	54	74	54	37	26	47	81	59	33	62	29
Polychaeta	0	0	24	0	37	0	52	6	37	22	0	34	52	0
Bivalvia	-	-	11	0	29	54	0	0	4	53	0	10	0	20
Gastropoda	7	0	9	83	68	62	0	0	43	-	0	23	42	0
All meroplankton	**33**	**16**	**40**	**39**	**36**	**49**	**37**	**21**	**26**	**62**	**54**	**31**	**43**	**26**
Site 2														
Cirripedia	40	22	39	40	55	41	32	24	nd	42	50	61	82	84
Polychaeta	50	14	35	50	15	54	14	14	nd	35	35	15	56	26
Bivalvia	17	0	40	0	0	-	0	0	nd	0	0	41	0	50
Gastropoda	62	16	57	23	100	-	10	0	nd	73	100	57	0	-
All meroplankton	**46**	**20**	**63**	**40**	**37**	**43**	**9**	**21**		**39**	**49**	**57**	**65**	**79**
Site 6														
Cirripedia	48	24	59	90	97	82	57	53	68	52	81	68	72	88
Polychaeta	20	21	41	67	58	0	26	35	47	21	50	82	54	79
Bivalvia	0	-	55	-	57	0	0	44	0	33	65	0	15	0
Gastropoda	27	12	68	12	47	-	-	0	0	100	50	50	0	0
All meroplankton	**45**	**24**	**55**	**63**	**80**	**76**	**49**	**51**	**53**	**37**	**71**	**61**	**55**	**86**

The mean values of biomass for cirripedes (Cir), polychaetes (Pol) and mollusks (Mol) at the three sites 2, 6, and 7 were not significantly different (t-tests, $p = 0.11 – 0.66$). The highest variability at all three sites was shown by the cirripede larvae. Contrary to biomass, the variability of the abundance of dead individuals was about the same both for the three groups of organisms and for the three sites. At the site 6 the mean values of dead individuals of cirripedes was 1.7 times as high as at the site 2 ($p = 0.014$) and for mollusks 2.2 times as high as at the site 7 ($p = 0.038$). The nutrient concentrations at the site 6 have exceeded the corresponding concentrations at the sites 2 and 7 by several fold, namely, for PO_4^{2-} the factors were 2.8 and 3.2 ($p = 0.001$ and 0.047), for NO_3^- 11.5 and 10.8 ($p < 0.001$ and < 0.001) and for NO_2^- 3.8 and 7.2 ($p = 0.200$ and < 0.001), accordingly for sites 2 and 7. As for NH_4^+, there were no differencies between the sites 2, 6 and 7.

In contrast, survival varied among the sites and groups. There were significantly higher proportions of dead larvae at site 6 compared to site 2 (cirripede larvae, $p = 0.014$) and site 7 (mollusc larvae, $p = 0.038$). There were also significant ($p < 0.05$) differences between site 6 and sites 2 and 7 in respect of PO_4^{2-} and NO_3^- but not NH_4^+.

In Sevastopol Bay, cirripede larvae were represented almost exclusively by one species – *Balanus improvisus* (Table 1). Nauplii of a second cirripede species (*Verruca splengleri*) were found only during the month of July 1999 at site 6 and 7 at a maximum abundance of 160 individuals·m^{-3}. In the course of 1999 large numbers of *B. improvisus* larvae were recorded in both May and August. All stages of nauplius development were found in the plankton, although the last cypris stage, was found only at site 6 in August 1999. During the period of the highest abundance in May 1999, the maximal abundance of living individuals was in the 0.2 mm size range representing the I-II ontogenetic stages (Table 3) at the bay outlet and in its top part of the Bay, when survival was high (more than 70 %). In the South Bay (Site 6), dead naupliars in the early stages reached 49 %, rising a little for the larger (older) stages 0.3 - 0.5 mm in size (Fig. 6A). August populations of *B. improvisus* larvae had a remarkably high proportion of dead individuals (53 – 90 % for the 0.2 mm size group, 38 – 70 % at other ontogenetic stages of development) in all regions of the bay with the highest values being recorded in the South Bay (site 6, Fig. 6B).

The numbers of living individuals at site 6 and 7 were low and approximately the same for all sizes. However in the top part of Sevastopol Bay (site 2), where the number of individuals of all sizes was lowest (38 – 53 %), density of living individuals decreased from 3458 individuals·m^{-3} for nauplii stages I-II to 249 individuals·m^{-3} for the final developmental stage (Table 3).

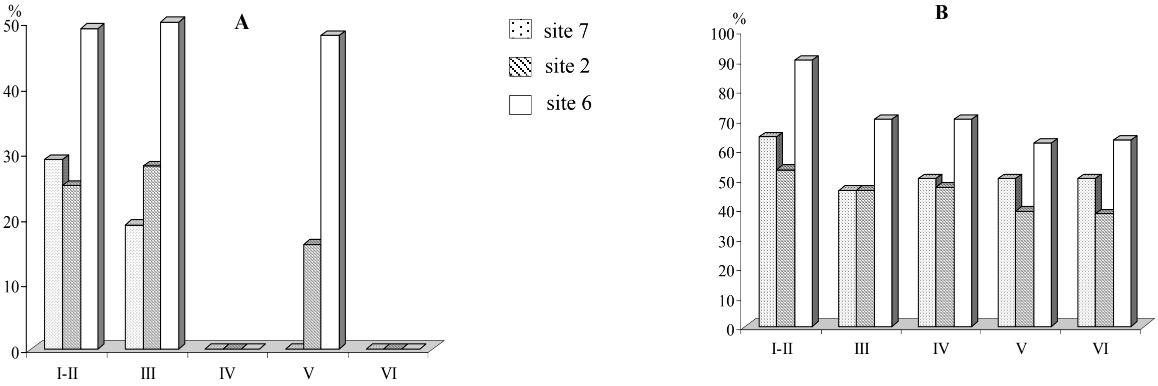

Fig. 6. Dead number individuals (%) by the ontogenetic stages of *Balanus improvisus* nauplii in Sevastopol Bay at sites 2, 6 and 7: A – May 1999, B - August 1999

Рис. 6. Число мертвых науплиусов *Balanus improvisus* (%) у особей разных стадий онтогенеза в Севастопольской бухте на станциях 2, 6 и 7: А – май 1999; В – август 1999

Table 3 The general abundance of the larvae Cirripedia by ontogenetic stages and standard error of the mean for the period May – October (V – X) 1999 in different regions of Sevastopol Bay
Табл. 3 Численность личинок Cirripedia по онтогенетическим стадиям развития и стандартная ошибка средней за период май - октябрь 1999 г. в трех районах Севастопольской бухты

Ontogenetic stages	Site Number	Abundance, ind.m^{-3}		
		V - X	V	VIII
I-II	7	612 ± 311	1315	54
	2	2777 ± 1588	3825	3458
	6	1090 ± 500	1463	199
III	7	331 ± 201	622	24
	2	763 ± 373	239	1032
	6	318 ± 143	285	237
IV	7	82 ± 28	0	12
	2	385 ± 330	0	822
	6	148 ± 67	0	115
V	7	62 ± 67	56	21
	2	225 ± 162	206	338
	6	113 ± 56	685	0
VI	7	25 ± 12	0	24
	2	54 ± 54	0	249
	6	41 ± 21	0	122

For polychaete larvae, highest abundances were recorded for *Polydora* sp. in June (site 7), July (site 2) and August 1999 (site 6) when all stages of development were found, but patterns of abundance and dead individuals among the size classes varied from site to site (Fig. 7).

The maximum percentage of dead individuals (58 %) was recorded at a size of 0.5 mm in all regions, but larvae of other sizes had relatively high survival (Fig. 7). At site 6, the maximum number of *P. sp.* larvae comprised the first two stages (0.2 and 0.3 mm) with a sharp decrease in abundance for the larger sizes following high mortality at 0.5mm. In contrast, at site 7 the larger size classes were more abundant despite the marked peak of mortality at 0.5 mm. At site 2 both abundance and the proportion dead were highest in the intermediate size classes (0.5 – 0.6 mm) and there were almost no living individuals found in the largest size class (Fig. 7), suggesting that living conditions in the South Bay were the least favourable for the survival of the larger planktonic larvae.

Canonical correlations (r_c) between the abundance of the dead individuals of cirripedes, polychaetes and mollusks and environmental variables (temperature, salinity, O_2, PO_4^{2-} , NO_3^-, NO_2^-, NH_4^+, SiO_3^-) were high and statistically significant ($r_c = 0.873$, $p = 0.006$). In the case of biomass of living individuals canonical correlation was also high and statistically significant ($r_c = 0.859$, $p = 0.028$), although we understand of the same our calculations' convention.

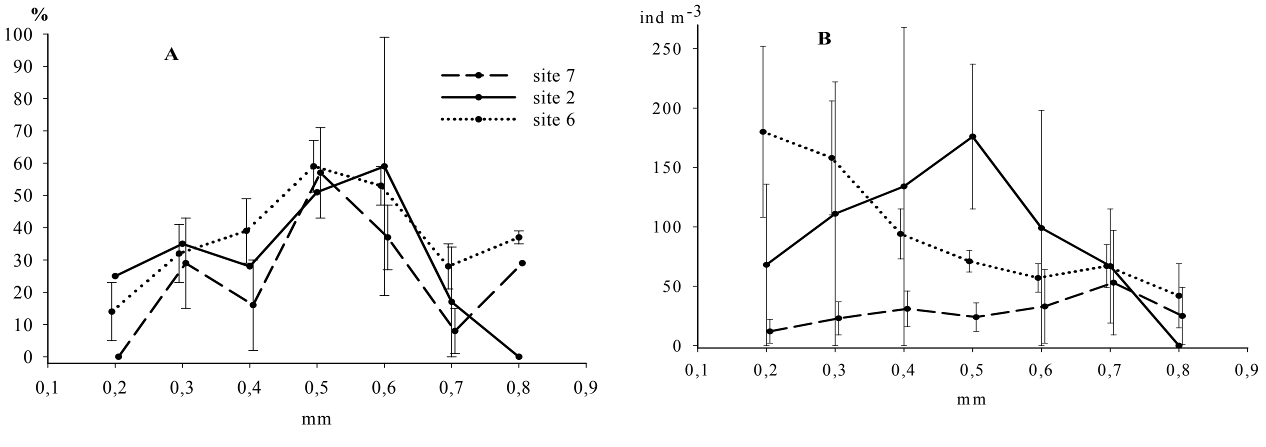

Fig. 7 Dead number individuals (%, A) and abundance of live individuals (individuals·m^{-3}, B) of *Polydora* sp. larvae of different sizes during May, July, and August 1999 in Sevastopol Bay at sites 2, 6 and 7
Рис. 7. Доля мёртвых (%, A) и численность живых организмов (экз·м$^{-3}$, B) у личинок *Polydora* sp. разного размера в течение мая, июля и августа 1999 г. в Севастопольской бухте на станциях 2, 6 и 7

Stepwise multiple regression was used to test the importance of individual variables (temperature, salinity, density, O_2, PO_4^{2-} , NO_3^-, NO_2^-, NH_4^+, SiO_3^-) as to which had the strongest influence on the abundance of dead individuals or biomass. Only significant values are shown for the first individual variables, such as standardized beta coefficient (b_s) and its p-value as well as multiple coefficient of correlation (r_m) when all variables were used in regression equation. Cirripede mortality (number of dead larvae) was positively influenced by NO_2^- ($b_s = 0.970$, $p \leq 0.001$) and salinity ($b_s = 0.958$, $p = 0.012$), and overall (all variables) the correlation was $r_m = 0.715$ with $p \leq 0.01$. Polychaete larval survival was negatively correlated with NO_2^- ($b_s = -1.388$, $p \leq 0.001$) and positively with NO_3^- ($b_s = 0.986$, $p \leq 0.002$), with an overall correlation of $r_m = 0.686$ and $p \leq 0.005$. There were no significant correlations of mollusc larvae survival or biomass with any of the ecological variables, whether taken individually or collectively. However, Cirripede biomass was positively correlated with NH_4^+ ($b_s = 1.10$, $p = 0.012$) and negatively with PO_4^{2-} ($b_s = -0.94$, $p = 0.035$) giving an overall $r_m = 0.713$ ($p = 0.017$) while polychaete biomass was positively related to O_2 ($b_s = 0.812$, $p \leq 0.001$) and negatively to NO_2^- ($b_s = -0.34$, $p = 0.020$) with again a highly significant overall correlation ($r_m = 0.795$, $p \leq 0.001$), although we understand of the same our calculation' convention.

Discriminant analysis was applied to the environmental variables temperature, salinity, and the concentrations of oxygen, PO_4^{2-} , NO_3^-, NO_2^-, NH_4^+, SiO_3^- and the biological variables either biomass or mortality (entered as the inverse of survival as % dead individuals) of cirripede, polychaete and mollusca. Site 6 formed a significantly distinct cluster in the space of the first and second canonical variables for both biomass and dead individual variables (Fig. 8).

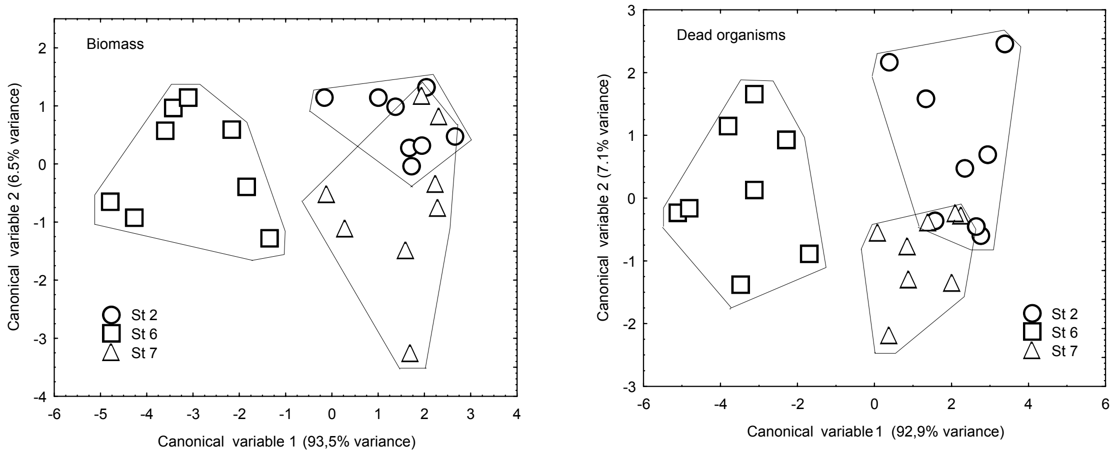

Fig. 8. Scatter plot of meroplankton biomass (mg m^{-3}, A) and mortality (% dead, B) canonical variable scores from the three sites in Sevastopol Bay (1998 – 1999)

Рис. 8. Диаграмма рассеяния отсчетов канонических переменных для биомассы (мг.$м^{-3}$, A) и смертности (% мертвых особей, B) меропланктона на станциях 2, 6 и 7 в Севастопольской бухте (1998 – 1999) гг.

In the case of biomass and environmental variables, the squared Mahalanobis distances (smd) and p-levels between sites 6 – 2 and 6 – 7 were smd = 24.70 and 24.73 and p = 0.014 and 0.014, respectively. In the case of dead individuals the statistics for the stated sites were smd = 36.22 and 26.17 and p = 0.003 and 0.011 respectively.

Sites 2 - 7 were not significantly different from each (smd = 2.23 and p = 0.942 for biomass and smd = 4.07 and p = 0.735 for survival).

For biomass, the first canonical variable accounted for 96 % of the explained variance. In this case the highest factor structure coefficients were for NO_2^- (-0.649) and NO_3^- (-0.505). These variables were primarily responsible for the discrimination of site 6 against sites 2 and 7 on

Fig. 8. For survival, the first canonical variable accounted for 94 % of the explained variance and its highest factor structure coefficients were for NO_2^- (-0.499), NO_3^- (-0.400) and mortality in cirripedes (-0.319) and these three variables made for the discrimination of site 6 from the other two.

Using the two-sample t-test for comparison of the mean values of this recent data with that from 1989/90 (Fig. 9) it can be seen that the average annual death ratio of polychaete larvae significantly increased (2.3 times) for the period from 1989 to 1999 ($t = -2.57$, $p < 0.05$, $t_{0.975} = 2.45$ for $f = 6$) while that of the cirripede larvae rose by a factor of 3.6 ($t = -4.09$, $p < 0.05$, $t_{0.975} = 2.45$ for $f = 6$). However, no significant differences were seen in survival between the two periods for either bivalve or gastropod larvae.

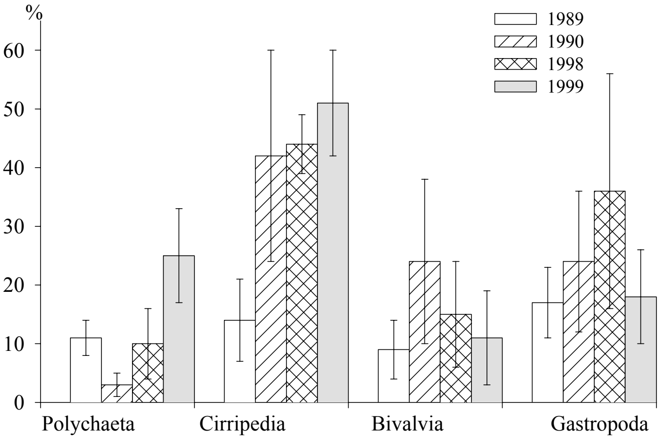

Fig. 9. Long-term changes in meroplankton mortality (% dead, mean ± standard error of the mean) of the four dominant taxa at the inlet of Sevastopol Bay (site 7) for the period May-October. Data for 1989 - 1990 from [34] and E. V. Pavlova (unpublished data)

Рис. 9. Долговременные изменения доли мертвых (% и стандартное отклонение средней) у четырех основных таксонов меропланктона в Севастопольской бухте на станции 7 за период май – октябрь 1989 – 1990 гг. Данные 1989 – 1990 гг. [34] и неопубликованные материалы Е. В.Павловой

Discussion. The spatial and temporal patterns of meroplankton distribution and abundance in Sevastopol Bay were consistent with the patterns in open North Atlantic waters [8] yet revealed marked differences among sites and also between the two years under study. In 1998, the abundance and the biomass for the total meroplankton and for the various taxa (Figs 4 and 5, table 2) were lower than in 1999. These differences were most pronounced at sites 2 and 6. The difference was noted also in the biodiversity of the planktonic communities for two periods, 1998 and 1999. These differences were marked and largely consistent, despite reservations which have been expressed over the use of diversity indices in such situations [48]. The differences appear to be driven firstly by natural changes in the hydrology of the Bay between the years and secondly by the differential anthropogenic pressures among the sites.

In the first half of 1998 the outflow from Sevastopol Bay, driven by high river input, dominated over the inflow of marine water into the bay. This gave rise to a general decrease in salinity [32]. The hydrological data showed that in June 1998 the salinity of the surface layers at site 7 dropped to 16.2 and at site 2, near to the mouth of the Black River, to 14.5. In September 1998, there was increase in salinity at both sites to pre-June values at 17.7 [14, 42]. The relatively sudden dilution of the seawater in Sevastopol Bay in 1998 may have been responsible for the increase in mortality and in this respect, the decrease in the abundance and biomass of the meroplankton (mainly cirripede and polychaete larvae). The water state was different in 1999. Strong the southern and southwestern winds favoured the inflow of the sea water from the Black Sea. In May 1999, water of salinity 18.0 ‰ occupied the whole lower layer of the bay and this inflow of water of salinity close to normal resulted in favourable conditions for survival and an increase in meroplankton abundance and biomass. Similarly [43] reported a tight link between estuaries in Washington State and the coastal ocean, in particular through changes in wind stress, although in their situation, many of the meroplankton were indifferent to salinity variation.

However, in June and July 1999, a fall in the wind energy and a prolonged rise in temperature reduced water advection, leading to stagnation in the water column. The increase of the biogenic elements and the decrease of oxygen' concentration were noted in the surface waters by June and especially by July. Hypoxic conditions resulted and bottom water oxygen concentrations fell to 50 % saturation over the whole of the Bay area [42]. The increased mortality of meroplankton, the hypoxia at sites 2 and 7 in June – July 1999 and the sharp decrease of H′ in August 1999 (Fig. 3) coincided with this water stagnation. In the South Bay the inflowing sea water driven by southern winds effectively prevented water exchange with the rest of Sevastopol Bay and heightened the impact of the anthropogenic inputs from industrial and diffuse runoffs [42]. These factors caused the increase in the meroplankton mortality in June - August 1999 (Table 2) and the decrease in diversity indices (Fig. 3).

Biological factors are suggested to have played little part in the adverse changes. The abundance of the meroplankton and zooplankton could have been affected by *Mnemiopsis leidyi* which is an active predator but, from the own samples' identification, observations made over the summer-autumn period, ctenophore abundance was approximately the same in 1998 and 1999 over all the sites. Consequently, ctenophore predation could not have been a prime cause of the differences in meroplankton over two years. The results presented here for meroplankton, correspond closely to other data on zoo- and ichthyoplankton and confirm the conclusion that plankton abundance and in particular its mortality are excellent indicators of the ecological status of the water body [13, 42]

The multivariate analyses showed that the biomass and survival of meroplankton (cirripedes, polychaetes but not mollusks) were closely related to nutrient concentrations with high coefficients (r_c) of 0.873 and 0.859, respectively. The common factor to the significant individual nutrient relationships found for cirripedes and polychaetes was the negative relationship with NO_2^- concentration. NO_2^- is an intermediary between NO_3^- and NH_4^+ (which themselves also showed a single significant correlation) in both nitrification and denitrification and so the implications of this relationship are unclear. It may signify a simple correlation of nutrient status (N, and possibly P) with survival and growth or it may indicate a more complicated situation in which the NO_2^- levels reflect an unbalanced system oscillating between oxic and anoxic conditions. The first explanation is unlikely, as both the other N correlations were positive, but there is some support for the latter, with a positive relationship of O_2 with polychaete biomass and evidence from the hydrodynamic data of hypoxia.

Other studies have shown that nutrients can have a number of different impacts on meroplankton. A.V. Silina and I.I. Ovsyannikova [46] showed that the increased pollution of the water and bottom sediments of Amursky Bay (Russia) during 1982 - 1995 by industrial and domestic sewage markedly affected the abundance of the larval pool and the food composition of the barnacle *Balanus rostratus*. O.G. Kusakin and A. P. Tsurpal [20] studied long-term changes in intertidal macrobenthos of Krabovaya Bay (Shikotan Island, Russia) exposed to different levels of organic pollution. Species with direct development increased while species with pelagic larva declined. Nitrite can have a direct toxic effect, and while most of the data refer to freshwater species, there are some for marine organisms. For instance D. Neumann et al. [29] found that an increase in nitrite concentration resulted in larval mortality and inhibition of development of fresh-water *Chironomus* even at very low concentrations (0.15 mg l^{-1}) which were within the range found in nature. The lowest water quality guideline proposed by [4] for nitrite for marine/brackish water organisms is 0.1 mg l^{-1}. A. D. Gordina et al [14] reported very low concentrations of nitrite of < 0.05µM outside the Bay, but levels of up to 0.15, 0.25 and 0.8µM at stations 7, 2 and 6 respectively. However, since 1.0 µM of nitrite is equivalent to just 0.06 mg l^{-1}, there seems little likelihood that nitrite was directly affecting meroplankton survival in this present study even at site 6.

It was been shown in previous researches [30, 33] that there is differential mortality in marine copepods depending on their developmental stage. M. D. Ohman and S. N. Wood [30] explained the increase in mortality in the copepod *Pseudocalanus newmani* at nauplii stages I – II and copepodite V by the improvement in the ability of the larvae to avoid predators. E. V. Pavlova [33] also reported statistically significant differences in the mortalities of *Acartia clausi* stages I – III nauplii compared to those of the copepodite I – II and V stages on the Sevastopol shelf. W. H. Lang and M. Marcy [21] recorded lowered survival of the I – II nauplia stages of *Balanus improvisus* in the laboratory due to their heightened sensitivity to environmental fluctuations and in particular to their nutritional status. A similar situation is reported here, and likewise, nutritional conditions may be invoked as a primary cause for the high mortalities in some larger (*i.e.* more developed) larvae.

The high mortality of *Polydora* sp. larvae of size 0.5 - 0.6 mm in this present study may be explained by a lack of food. Having reached the 9-segment stage (0.6 mm), the larvae of this species change to predatory feeding, actively capturing and devouring copepod nauplii, cirripede first stage nauplii and bivalve veligers from 50μm to 150μm in size [10, 16]. During the periods of the highest quantitative development of *Polydora* sp. larvae in Sevastopol Bay (June-August, 1998), a low abundance was recorded of their preferred prey organisms. Thus, in June (site 7) and July (site 2) the abundance of their prey (cirripede nauplii) was half that at site 6 in August (Fig. 4, Table 3). Thus, this could be the cause of differences in mortality of the larger (> 0.5 mm) *Polydora* sp. larvae compared to the other sizes. At sites 2 and 7 there was a recorded increase in the mortality of *P. sp.* with a concomitant decrease in the abundance of prey; at site 6, the increase in the prey resulted in a lower mortality of the larger-sized larvae (Fig.7). Therefore, death of larvae at a definite ontogenetic stage of development primarily as a response to environmental changes was linked to the deterioration in the habitat. Our field results validate laboratory studies [44] linking survival and age for larvae of *B. improvisus* and *Polydora sp.* and also the findings of P.J. Hansen et al.[15] in which feeding efficiencies declined with size.

As was stated above, long-term data on quantitative parameters for Sevastopol Bay meroplankton are scarce. However, compared to the situation reported for 1989 [26] there has been an increase in mortality of two of the most abundant groups of meroplankton over this period. This is evidence of the continuing deterioration of the ecological status of Sevastopol Bay. This decline in quality was not supported by the data on molluscan larvae. While J. A. Pechenik [36] was of the opinion that the relatively hard shell of molluscan larvae might offer protection from external ecological stresses, such a defence is at best temporary and longer-term physiological tolerance mechanisms must be involved. The meroplankton decline in Sevastopol bay seems also to reflect a wider decline in the Black Sea plankton [47].

Conclusion. Two-year monitoring of meroplankton in three areas of Sevastopol Bay subject to different degrees of nutrient enrichment yielded a total of 40 species of pelagic larvae belonging to 32 families of benthic invertebrates. The area at the bay inlet, where all the species were found, had the greatest species diversity, whilst, the more polluted South Bay had the lowest (30 species). The patterns of the abundance, biomass and dead number of the meroplankton were the result of a complex interaction between the plankton organisms and both natural and anthropogenic environmental factors. The highly indented coastal topography and consequent isolation of embayment results in the differential control and expression of meroplankton populations. Canonical and discriminant analyses have shown that there were statistically significant correlations between the biomass and the survival of some meroplankton groups and environmental variables, and that the ecosystem of Sevastopol Bay can be subdivided into two subecosystems. The most unfavourable conditions were found at the top part of Sevastopol Bay and in the South Bay, in which plankton communities showed markedly lower total abundance and markedly lower survival than in the reference shelf area outside the Bay both in 1998 and in 1999.

Species composition, quantity and the survival of planktonic organisms can serve as sensitive indicators of ecosystem status. The mortality of polychaetes and of cirripedes were the most sensitive variables to the eutrophication stress and it was the early ontogenetic stages that were shown to be the most sensitive to environmental change. On the basis of the data for the mortality of cirripede and polychaete larvae, the ecological status of Sevastopol Bay has been deteriorating for the last 10 years.

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1. *Afifi A. A., Azen S. P.*. Statistical analysis. A computer oriented approach. – Acad. Press, N.Y. – 1979. - P. 127 – 132.
2. *Alexandrov B. G., Ablov O. A.* Method of marine zooplankton coloration // Bulletin of Inventions. - 1988. - № 21 – P. 1 - 6. (in Russian).
3. *Alexandrov B. G., Zaitzev J. P.* Anthropogenic influence on the coastal zone neuston and methods of its estimation // Biologiya Morya. - Vladivostok. - 1989. - № 2 - P. 56 - 60 (in Russian).
4. *Australian* and New Zealand Guidelines for fresh and marine water quality. – The Guidelines ANZECC/ARMCANZ. Department of the Environment and Heritage, Canberra. 2000. – **1**. – P 63 – 68.
5. *Belgrano A. P., Legendre J., Dewarumez M., Frontier S.* Spatial structure and ecological variation of meroplankton on the French-Belgian coast of the North Sea // Mar. Ecol. Progr. Ser. – 1995. – **128.** - P. 45 - 30
6. *Belgrano A. P., Legendre J., Dewarumez M., Frontier S* Spatial structure and ecological variation of meroplankton on the Dutch coast of the North Sea // Mar. Ecol. Progr. Ser. - 1995. - **128**. – P. 51 - 59.
7. *Bullard S. G., Lindquist N. L., Hay M. E.* Susceptibility of invertebrate larvae to predators: how common are post-larval capture defenses? // Mar. Ecol. Progr. Ser. - 1999. – **191.** – P. 153 - 161.
8. *Byrne P. M.* Seasonal composition of meroplankton in the Dunkellin estuary, Galway bay // Biology and Environment: Proc. R. Irish Acad. – 1995. - **95B,** № 1. – P. 35 - 48.
9. *Chuhchin V. D.* Pelagic larvae of Gastropoda from the Black Sea // Trudy Sevast. Biol. Stanzii. - 1960. – **13**. – P. 92 - 113 (in Russian).
10. *Daro M. H., Polk P.* The autecology of *Polydora ciliata* along the Belgian coast // Netherlands J. Sea Res. - 1973. – **6** – P. 130 - 140.
11. *Dixon W. J., Brown M. B.* BMDP-79. Biomedical computer programs, P-Series. - Berkley, Univ. California Press. - 1979. – 880 p.
12. *Edwards M., Beaugrand G., Reid P. C., Rowden A. A., Jones M. B.* Ocean climate anomalies and the ecology of the North Sea // Mar. Ecol. Progr. Ser. - 2002. – **239**. – P. 1 - 10.
13. *Gordina A. D., Pavlova E. V., Ovsyany E. I., Romanov A. S., Kemp R. B., Wilson J. G., Repetin L. N.* The state of the plankton community as an indicator of environmental conditions // 3rd INTAS Interdisciplinary Symposium on general biochemistry, biotechnology and environment. (Grant Monitoring Conference), Moscow University and INTAS Secretariat, Proceeding Book. MAX Press, Moscow - 2000. - P. 23 - 24.
14. *Gordina A. D.,. Pavlova E. V, Ovsyany E. I., Wilson J. G., Kemp R. B., Romanov A. S.* Long-term changes in Sevastopol Bay (the Black Sea) with particular reference to the ichtyoplankton and zooplankton // Estuarine, Coastal and Shelf Science – 2001. – **52**. – P. 1 - 13.
15. *Hansen P. J., Bjornsen P. K., Hansen B. W.* Zooplankton grazing and growth: Scaling within the 2 – 2.000 μm body size range // Limnol. and Oceanography - 1997. – **42**. - P. 687 - 704.

16. *Johnson K. B.* Predation on planktonic marine invertebrate larvae: Thesis Degree Ph. D. - Ann Arbor. – 1998. - 169 p., www.umi.com.
17. *Kisseleva M. I.* Pelagic larvae of Polychaeta from the Black Sea // Trudy Sevast. Biol. Stanzii. - 1957. – **9.** – P. 58 - 112 (in Russian).
18. *Konsulov A.* Distribution of *Mytilus* larvae in the Black sea near Bulgarian coasts // Fisheries Economy - 1980. – № 27. – P. 24 - 26 (in Bulgarian).
19. *Kravets V. N., Monina T. L.* Pollution level in Sevastopol Bay and the Crimea southern coast in 1992-96. / V.N. Eremeev (ed.), Diagnosis of the Black Sea ecosystem state and the region of village Katsyveli (Crimea). Marine Hydrophysical Institute, Sevastopol. - 1997. - P. 55 - 56 (in Russian).
20. *Kusakin O.G., Tsurpal A.P.* Long-term changes in intertidal macrobenthos of Krabovaya Bay (Shikotan Island) at different levels of organic pollution // Biologiya Morya. – Vladivostok. - 1999. – **25.** – P. 209 - 216. (in Russian).
21. *Lang W. H., Marcy M.* Some effects of early starvation on the survival and development of barnacle nauplii, *Balanus improvisus* (Darwin) // J. Exper. Mar. Biol. Ecol. – 1982. – **60**. – P. 63 - 70.
22. *Makarov J. N.* Red Book of Ukraine (Decapoda). — Ukrainian Encyclopedia, Kiev. - 1994. - P. 48 - 55 (in Ukrainian).
23. *Murina V. V.* Veligers of Gastropoda in meroplankton of the mussel farm in Laspi (southern shore of the Crimea) // Ecologiya moray. - 1990. – Вып. 36 - P. 27 - 34 (in Russian).
24. *Murina V. V.* Black Sea meroplankton: history of study and modern problem // Mar. Ecol. J. - 2003.- **II**. - № 3. – P. 41 - 50 (In Russian).
25. *Murina V. V., Artemjeva J. N.* Phenology of molluscan pelagic larvae from the southern coastal waters of Crimea // Ecology of marine mollusks. Scientia Marina. Eds. J. D. Rosand, guerra (Supplement 2): - 1997. – **61**. - P. 55 - 58.
26. *Murina V. V., Lisitskaya E. V., Anosov S. E.* The species composition of the meroplankton as the index of the ecological situation in Sevastopol Bay / E.V. Pavlova and N.V.Shadrin (eds), Sevastopol aquatory and coast: ecosystem processes and services for human society. Aquavita, Sevastopol. - 1999. - P. 149 - 158 (in Russian).
27. *Murina V. V., Lisitskaya E. V., Shalyapin V. K.* Larvae of abundant species of bottom invertebrates in plankton of Sevastopol Bay // Hydrobiol. J. - 2001. – **37**. - № 2. – P. 13 - 20 (in Russian).
28. *Murina V. V., Nicolaenko T. V.* Polychaete meroplankton of the mussel farm in Laspi // Ecologiya morya, Sevastopol. - 1990. – Вып. 36 – P. 34 - 37 (In Russian).
29. *Neumann D., Kramer M. I., Raschke B., Graefe B.* Detrimental effects of nitrite on the development of benthic *Chironomus* larvae, in relation to their settlement in muddy sediments // Archiv für-Hydrobiologie - 2001.- **153** – P. 103 - 128.
30. *Ohman M. D., Wood S. N.* Mortality estimation for planktonic copepods: *Pseudocalanus newmani* in a temperate fjord // Limnol. and Oceanography. - 1996. – **41**. – P. 126 - 135.
31. *Oviatt C.* The changing ecology of temperate coastal waters during a warming trend // Estuaries. - 2004. – **27**. – P. 895 - 904.
32. *Ovsyany E. I., Kemp R. B., Repetin L. N., Romanov A. S.* Hydrological and hydrochemical regime of Sevastopol Bay in conditions of anthropogenic influence / V.A. Ivanov (ed.), Ecological security of coastal zone and application of shelf zone resources. Marine Hydrophysical Institute, Sevastopol. - 2000. – P. 79 - 103 (in Russian).
33. *Pavlova E. V.* Survival of *Acartia clausi* Giesbr. near the Crimean coasts / E.V. Pavlova and N.V. Shadrin (eds), Sevastopol aquatory and coast: Ecosystem processes and services for human society. – Aquavita, Sevastopol. - 1999 - P. 211 - 220 (in Russian).
34. *Pavlova E. V., Kuftarkova E. A.* Anthropogenic impact on the planktonic communities / E. Ozhan, (ed.) Proceeding of the Second International Conference on the Mediterranean Coastal Environment. Terragona, Spain.- 1995.- P. 67 - 74
35. *Pavlova E. V., Ovsyany E. I., Gordina A. D., Romanov A. S., Kemp R. B.* Modern state and tendencies of change in Sevastopol Bay / E.V. Pavlova and N.V. Shadrin (eds), Sevastopol aquatory and coast: Ecosystem processes and services for human society. Aquavita, Sevastopol. - 1999 - P. 70 - 94 (in Russian).
36. *Pechenik J. A.* On the advantages and disadvantages of larval stages in benthic marine invertebrate life cycles // Mar. Ecol. Progr. Ser. - 1999. – **177**. – P. 269 - 297.
37. *Petipa T. S.* Average weight of Black Sea zooplankton forms // Trudy Sevast. Biol. Stanzii. - 1957. – **9**. - P. 39 - 57 (in Russian).

38. *Petipa T. S., Pavlova E. V.* Mortality of zooplankton in Sevastopol Bay // Reports of National Academy of Sciences of Ukraine. – 1995. - **6** - P. 146 - 148. (in Russian).
39. *Petran A. V.* Variations de densite des veligeres de bivalves dans la zone a petite profondeur du littoral Roumain de la mer Noire // Rapp. Proc.-Verb. Reunions / CIESM (Monaco). - 1977. – **24. -** P. 153 - 154.
40. *Polikarpov G. G., Zaitsev J. P., Zats V. I., Radchenko L. A.* Pollution of the Black Sea (levels and sources) // Proc. of the Black Sea symp. Ecological problems and Economical prospects. Istanbul, Turkey. - 1994. - P. 15 – 38.
41. *Reid P. C., Battle E. J. V., Batten S. D., Brander K. M.* Impacts of fisheries on plankton community structure // ICES J. Mar. Science. - 2000. – **57**. – P. 495 - 502.
42. *Repetin L. N., Gordina A. D., Pavlova E. V., Romanov A. S., Ovsyany E. I.* Effect of oceanographic factors upon the ecological state of Sevastopol Bay (the Black Sea) // Mar. Hydrophys. Journ. - 2003. – **2**. – P. 66 - 80 (in Russian).
43. *Roegner G. C., Armstrong D. A., Hickey B. M., Shanks A. L.* Ocean distribution of Dungeness crab megalopae and recruitment patterns to estuaries in southern Washington State // Estuaries. - 2003. - **26** – P. 1058 - 1070.
44. *Rumrill S. S.* Natural mortality of marine invertebrate larvae // Ophelia. - 1990. – **32**. – P. 163 - 198.
45. *Selifonova J. P.* Seasonal and long-term dynamic of the zooplankton community in Novorossiysk bay of the Black Sea exposed to anthropogenic impact // Acta Zool. Bulgarica. - 2000. – **52**. - P. 63 - 74.
46. *Silina A. V., Ovsyannikova I. I.* Interannual and seasonal dynamics of recruitment and growth of the young barnacle in Amursky Bay, the Sea of Japan // Biologiya morya. – Vladivostok. - 2000. – **26**. - № 3. – P. 175 - 181.
47. *Siokou F., Shiganova T., Christou E. D., Kamburska L., Gubanova A., Konsulov A., Musaeva E., Skryabin V., Khoroshilov V.* Mesozooplankton communities in the Aegean and Black seas: a comparative study // Mar. Biol. - 2004. – **144** – P. 1111 - 1126.
48. *Wilson J. G., Jeffery D. W.* Benthic biological pollution indices in estuaries (chapter 12) / K.J.M. Kramer (ed.) Biomonitoring of coastal waters and estuaries. Baton Rouge CRC Press. - 1994. - P. 311 - 327.
49. *Zachvatkina K. A.* Bivalvia larvae of the Sevastopol region of the Black Sea // Trudy Sevast. Biol. Stanzii. - 1959. – **11**. – P. 108 - 151 (in Russian).

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Річна динаміка чисельності, біомаси і виживання меропланктону в Севастопольській бухті, Чорне море. **Є В. Павлова, В. В. Муріна, Р. Б. Кемп, Д. Г. Вільсон, В. П. Парчевський.** Узагальнено дані по видовому складу, чисельності, біомасі й виживаності меропланктону в Севастопольській бухті (Чорне море). Аналіз змін гідрохімічних і гідрологічних умов у 1998 і 1999 рр. показав їхній вплив на біологічні особливості представників меропланктону різних таксономічних груп і розмірів тіла. Дискримінантний аналіз дав можливість знайти в бухті дві пелагічні підсистеми, які добре відрізняються. Порівняння життєздатності меропланктону за період 1989-1999 рр. виявило її зниження у представників Polychaeta і Cirripedia.

Ключові слова: чисельність, біомаса, виживаність, меропланктон, середовище, Севастопольська бухта, Чорне море (Україна)

Годовая динамика численности, биомассы и выживаемости меропланктона в Севастопольской бухте, Черное море.Е В. Павлова, В. В. Мурина, Р. Б. Кемп, Д. Г. Вильсон, В. П. Парчевский**.** Обобщены данные по видовому составу, численности, биомассе и выживаемости меропланктона в Севастопольской бухте (Черное море). Анализ изменений гидрохимических и гидрологических условий в 1998 и 1999 годах показал их влияние на биологические особенности представителей меропланктона разных таксономических групп и размеров тела. Дискриминантный анализ дал возможность обнаружить в бухте две хорошо различающиеся пелагические подсистемы. Сравнение жизнеспособности меропланктона за период 1989-1999 гг. выявило её снижение у представителей Polychaeta и Cirripedia.

Ключевые слова: численность, биомасса, выживаемость, меропланктон, среда, Севастопольская бухта, Черное море (Украина)