

PROPORTION OF BACTERIA IN TOTAL PLANKTON OF THE CENTRAL ADRIATIC

UDIO BAKTERIJA U UKUPNOM PLANKTONU SREDNJEG JADRANA

Nada Krstulović and Slavko Šobot

Institute of Oceanography and Fisheries, Split

Quantitative presence of bacteria in total plankton was studied in the coastal area and on the high sea of the centrale Adriatic in 1980. The results indicate that the proportion of bacteria in total plankton biomass is considerable. In the coastal sea bacterial carbon was, on an average, 11.49‰ and in the high sea 12.04‰ of total planktonic carbon assessed from the ATP quantity.

INTRODUCTION

The role of bacteria in the biological production of marine environment is very important and complex. Planktonic bacteria are capable of utilizing diluted organic matter (DOM) and transform it in particulate organic matter (POM). Therefore bacteria are significant link in the natural food chain. Owing to their significance bacterial biomass has been the subject of many studies (Moriarty, 1979; Hobbie et al., 1977; Watson et al., 1977) as well as the bacterioplankton growth (Hagström et al., 1979; Fuhrman and Azam, 1980). The results were compared with the distribution of nutrients, phytoplankton and other parameters on which the (quantitative) presence of bacterioplankton depends (Ferguson and Rublee, 1976; Palumbo and Ferguson, 1978; Fuhrman et al., 1980; Larsson and Hagström, 1979).

This paper is an attempt to determine the quantitative presence of bacteria in the central Adriatic total plankton in different seasons.

MATERIAL AND METHODS

Samplings ere seasonally carried out at 6 stations in the coastal region and at one high-sea station during 1980 (Fig. 1). Samples were collected from three layers (surface, intermediate and interface) in the coastal area and from seven levels (0, 10, 20, 30, 50 75 and 100 m) at the high-sea station.

Total direct counts of bacteria were made by filtering aliquots of sea water samples, using $0.2\ \mu\text{m}$ Nucleopore filters (stained by irgalan black colour), and staining the samples with 0,01% acridine orange for 3 min (Hobbie et al., 1977). The filters were viewed by epifluorescence microscopy, and 20 fields per samples were counted to determine total numbers of planktonic bacteria.



Fig.1. Sample locations

ATP was extracted and analysed in samples after the Holm-Hansen and Booth's method (1966). ATP was extracted in hot tris buffer for five minutes and thereupon the samples were frozen until analysis. The analysis was carried out by ATP-photometer (JRB Model 3000) by the use of luciferase enzyme.

RESULTS AND DISCUSSION

Total number of planktonic bacteria varied within the $2.5\text{--}30.2 \times 10^5$ cells ml^{-1} range (Table 1). Minimum mean values were recorded in the coastal area in winter (4.2×10^5 cells ml^{-1}) and maximum in autumn (10.2×10^5 cells ml^{-1}). In general, in the coastal area total bacterial number increased from winter to autumn whereas in the open sea a slight decrease was observed in the spring period (Table 2). Further, total number of bacteria in the coastal area was higher what may be understood in terms of the higher quantities of available organic matter of mainly allochthonous origin. Similar results were obtained earlier for this area, as well (Cvijić, 1955; Ristić and Letić, 1972).

The proportion of bacteria in total plankton was determined on the basis of assessed bacterial carbon (Ferguson and Rublee, 1976) and comparison with the obtained ATP values transformed in total planktonic carbon by factor 250 (Holm-Hansen, 1973).

Mean seasonal values of bacterial carbon quantity varied between minimum $2.57\ \text{mg C m}^{-3}$ in winter to maximum $9.63\ \text{mg C m}^{-3}$ in autumn. The mentioned results are comparable with those of Ferguson and Rublee (1976).

Table 1. Total number of bacteria for all investigated stations

Station	Depth	Total no. of bacteria (cells $\times 10^5$)			
		Winter	Spring	Summer	Autumn
1	0	6.8	4.8	5.5	11.1
	20	5.4	3.4	5.6	10.3
	40	2.5	4.4	7.7	9.2
2	0	3.4	3.3	5.6	7.6
	20	2.5	2.5	4.1	6.8
	40	3.9	3.3	6.4	7.7
3	0	3.3	3.3	6.0	8.6
	20	3.3	2.6	3.8	8.3
	40	3.5	4.0	4.2	8.0
4	0	3.8	7.1	7.9	30.2
	20	4.6	12.9	7.1	14.2
	35	5.1	16.7	6.3	12.4
5	0	4.0	3.4	5.1	9.7
	10	2.3	2.6	4.1	7.9
	20	6.2	3.3	4.2	7.1
6	0	6.6	4.9	4.4	9.8
	20	3.9	4.3	4.5	7.8
	40	4.5	4.7	5.1	7.5
7	0	5.1	4.7	3.9	7.4
	10	3.3	5.6	3.5	7.1
	20	5.3	3.9	4.2	6.1
	30	4.4	3.7	4.7	7.1
	50	5.6	5.6	3.9	4.1
	75	4.5	3.9	5.2	5.0
	100	3.8	3.7	5.9	6.5

Table 2. Mean values of total number bacteria

Season	No. bacteria (cells $\times 10^5$)	
	Coastal sea	Open sea
Winter	4.2	4.6
Spring	5.7	3.5
Summer	5.4	4.7
Autmun	10.2	6.2

Seasonal variations of mean ATP carbon in the open sea ranged from 8.22 mg m^{-3} in autumn to 55.20 mg m^{-3} in spring. These values were considerably higher in the coastal sea and an average quantity of total planctonic carbon varied from 36.39 mg C m^{-3} in spring to 83.02 mg C m^{-3} in summer. Bacterial carbon made up from 4.89%—44.77% of total ATP carbon (Table 3). This range is similar to that recorded by Palumbo and Ferguson (1978). The proportion of bacteria in total plankton of both the coastal and open sea was highest in autumn.

Table 3. Means of bacterial carbon (B—C), ATP carbon (ATP—C) and proportion of bacterial carbon in the total planktonic carbon (% B—C)

	Coastal sea			Open sea		
	B—C (mg C m ⁻³)	ATP—C (mg C m ⁻³)	% B—C	B—C (mg C m ⁻³)	ATP—C (mg C m ⁻³)	% B—C
Winter	2.57	38.63	6.65	2.74	20.40	13.14
Spring	4.19	36.39	11.51	2.68	55.20	4.85
Summer	6.70	83.02	8.07	3.69	22.49	16.41
Autumn	9.63	42.82	22.49	3.68	8.22	44.77
Mean	5.77	50.22	11.49	3.20	26.58	12.04

Lower bacterial biomass values and proportion in total ATP carbon were found by Fuhrman et al., (1980) are due to the lower average bacterial volume ($0.46 \mu\text{m}^3$) rather than to their greater abundance than that recorded by our studies. In this paper the mean volume was calculated by samples. It was established that it varied considerably (from 0.07 — $0.13 \mu\text{m}^3$).

The observations of vertical distribution of bacterial carbon and ATP carbon in the coastal area show that both values decreases going down from surface to the medium depth wherefrom they increase going deeper to the bottom (Fig. 2). Bacterial carbon makes up 8.4% of total plankton at surface,

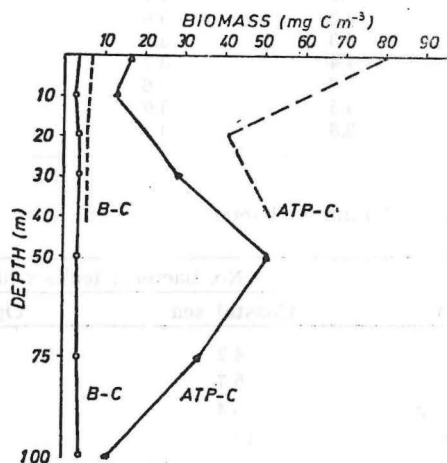


Fig. 2. Vertical distribution of bacterial and planktonic biomass

12.40% in the medium layer and 11.01% in the bottom layer. At the high sea station the percentage of bacterial carbon decreases going down from surface where it is 22.32% to 6.07% at 50 m and increases going deeper to reach 31.31% on the bottom. Generally speaking, the proportion of bacteria in total plankton is slight higher in the open sea.

The analysis of the obtained results led us to conclude that the bacterial number varies mainly owing to the geographical position and land effects. Bacterial number were not significantly correlated with ATP. The same was established by Palumbo and Ferguson (1978) and Ferguson and Rublee (1976) in the similar investigations carried out in the coastal area of northern Carolina.

CONCLUSIONS

Bacteria make up a substantial portion of total plankton biomass. It was established that both the biomass of bacteria and of total plankton in the coastal area exceeds considerably of that in the open sea. However, the proportion of bacteria in total plankton is approximately the same in both study areas.

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Nada Krstulović i Slavko Šobot

Institut za oceanografiju i ribarstvo, Split

KRATAK SADRŽAJ

Kvantitativna zastupljenost bakterija u ukupnom planktonu istraživana je sezonski na šest postaja priobalnog dijela i jednoj pučinskoj postaji srednjeg Jadrana.

Ukupan broj bakterija je određivan metodom izravnog brojenja pomoću epifluorescentne mikroskopije. Udio bakterija u ukupnom planktonu određivan je na osnovu procjene bakterijskog ugljika iz ukupnog broja i prosječnog volumena stanica i upoređivanja s ukupnim planktonskim ugljikom. Procjena planktonskog ugljika vršena je na osnovu mjerenih ATP vrijednosti i pomnoženih s faktorom 250.

Zapaženo je da bakterije zauzimaju znatan udio u ukupnoj planktonskoj biomasi. U priobalnom moru bakterijski ugljik je iznosio u prosjeku 11.49%, u pučinskom 12.04% od ukupnog planktonskog ugljika.

Biomasa bakterija i ukupnog planktona bila je znatno veća u priobalnom dijelu gdje je prosječna količina bakterijskog ugljika iznosila 5.77 mg m^{-3} , ATP ugljika 50.22 mg m^{-3} . Na otvorenom moru te vrijednosti su iznosile za bakterijski ugljik 3.20 mg m^{-3} , za ATP ugljik 26.58 mg m^{-3} .

Analizirajući sezonsko učešće bakterija u ukupnom planktonu zapaženo je da su najvećim postotkom zastupljene u jesenskom periodu.