HOW MUCH DO BACTERIA DEPEND ON PHYTOPLANKTON METABOLISM?

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Abstract
The degree of coupling between phytoplankton and bacteria was estimated in the Bay of Palma during summer 2002 by comparing the relative proportions of particulate and dissolved primary production with bacterial carbon demand. On the whole, these results suggest, that the bacterial growth efficiency responds to changes in phytoplankton production, increasing as the primary production increases. In summary, there is lack of dependence of bacterial metabolism on algal production in the oligotrophic area, whereas the most productive area showed a strong coupling between phytoplankton and bacterioplankton.

Keywords: Bacterial metabolism, PER, oligotrophy, BGE

Introduction

The production of dissolved organic carbon (DOC) is important in oceanic biogeochemistry and there are many different mechanisms of production although the ultimate source is phytoplankton. Dissolved primary production (DOC-pr) in marine systems has been often ignored because it is considered to be very low compared with the particulate fraction (POC-pr). Some authors (1) have suggested that the rate of POC-pr and the relative contribution of DOC-pr to total carbon fixation (PER) are inversely correlated, although other authors (2) have reported that PER is constant across marine and freshwater systems. Thus the issue, still unresolved, is important, since dissolved organic carbon represents an important source of labile carbon for heterotrophic bacteria(3). Depending on the bacteria growth efficiency (BGE), DOC consumed by bacteria will be either converted to POC or respired as CO_2 decreasing the organic carbon transfer to higher trophic levels. Both processes of bacterial metabolism, production and respiration, against the general idea are not well coupled, providing a metabolic flexibility necessary for survival under oligotrophic conditions (4). According to a recent study (5) the carbon cycle is mainly determined by the combined activities of bacteria and phytoplankton. Therefore, variations in BGE will affect the degree of coupling between bacteria and phytoplankton and, consequently, the biogeochemical cycles within marine ecosystems. Given the lack of simultaneous measurements of the BGE and the balance between DOC-pr and POC-pr, particularly in oligotrophic regions (although they cover ca 70% of the total marine surface), we have carried out the present experiment.

Material and methods

The study was conducted at Bay of Palm during June 2002. The water samples were collected at four depths between surface and 15 or 30 m depth. For phytoplanktonic POC-pr and DOC-pr rates, the seawater samples were dispensed into 30 ml glass bottles (three clear and one dark), spiked with 740 Kbq (20 µCi) $NaH^{14}CO_3$ and incubated *in situ* during the daylight period (12 h). Bacterial production (BP) was estimated as the rate of radioactive Leucine incorporation (6). For bacterial respiration (BR), the seawater samples were filtered, using a gentle filtration system (0.8 µm). The filtered water was incubated in 60 ml borosilicate glass bottles at *in situ* temperature (± 1 ºC) in the dark over 12, 24 and 48 h.

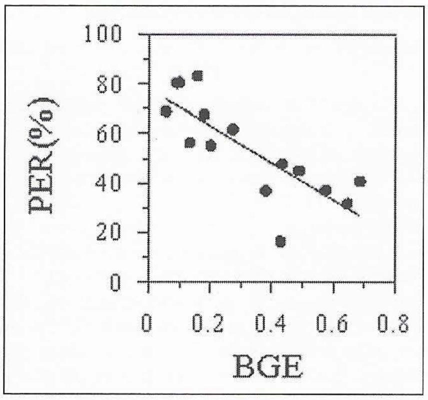
Results

We observed two contrasting regions within an oligotrophic aquatic system (Table 1). The percent of extracellular release (PER) was significantly lower within the most productive areas. However, bacterial production (BP) and BGE were higher in the most productive areas. BGE increased as the relative contribution of DOC-pr to total carbon fixation decreased (Fig. 1).

Table 1.-Mean (± SE) values of total carbon fixation (TOC-pr), percent of extracellular release (PER), bacterial production (BP), bacterial growth efficiency (BGE) and bacterial carbon demand (BCD) during summer 2002 in the Bay of Palma.

Bay of Palma (Summer 2002)	TOC (mg C m^{-3} h^{-1})	PER (%)	BP (pmol Leu L-1 h-1)	BGE (%)	BCD (% of TOC)
Bahía Posidonia	1.50 ± 0.30	69 ± 4	344 ± 56	44 ± 4	88 ± 21
Cap Enderrocat St 4	0.35 ± 0.09	37 ± 4	14 ± 4	6 ± 1	211 ± 43

Conclusions



The relative contribution of DOC-pr to total primary production decreases as the productivity of the system increases. In agreement with a recent study (7), this result provides evidence that PER is not constant, even within oligotrophic waters.

There was an important bacterial response to the variability in primary production by adapting their metabolism to this oligotrophic environment. BGE responded to changes in phytoplankton production, increasing as the primary production increased.

The organic carbon was consumed by bacteria less efficiently within the most oligotrophic area and most of the carbon was respired. Whereas the area with higher primary production, the energetic cost of bacterial growth appeared to decrease and therefore BGE increased.

There was a clear evidence of the small scale spatial variability within this oligotrophic aquatic system showing lack of dependence of bacterial metabolism on algal production within the less productive area, and strong coupling between phytoplankton and bacterioplankton within the most productive area.

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