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Dynamics of bacterial respiration and related growth efficiency, dissolved nutrients and dissolved oxygen concentration in a subarctic coastal embayment

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Abstract. Temporal variations in dissolved oxygen, nutrient concentrations and oxygen utilization rates (<0.7 µm fraction) were recorded for almost two years in the subarctic Funka Bay, Japan. Dissolved inorganic nitrogen ranged from 0 to 26 µM, phosphate from 0 to 2 µM and silicate from 1 to 64 µM. There was evidence of nitrogen limitation. Dissolved oxygen concentration ranged from 130 to 440 µM, and decreased to <150 µM in the bottom layer in summer. The rate of oxygen utilization, attributed to bacterial respiration, ranged from 0.6 to 9.3 µM day^{-1} at 10 m depth, and from 0.8 to 5.0 µM day^{-1} at 90 m depth, and was the principal mechanism causing the decrease in dissolved oxygen in the bottom layer in the summer. Bacterial growth efficiencies calculated for the 10 m and 90 m depths were similar: 1.6–17.2% and 1.4–23.6%, respectively. With the bacterial growth efficiencies <25%, the bacteria in Funka Bay acted as a net sink of carbon, where >75% of the organic matter flux through bacteria could be mineralized to CO_2.

Introduction

In the microbial loop, bacterial production is the key process originating the flux of dissolved organic matter (DOM), with the bacteria playing roles as both mineralizers and recyclers (e.g. Ducklow and Carlson 1992; Simon *et al.* 1992). However, whether the bacteria act as a link (recyclers) or a sink (mineralizers) depends on the bacterial growth efficiency (BGE) (del Giorgio and Cole 2000). BGE is estimated by comparing gross with net production, where gross production has been measured as production plus respiration (Chin-Leo and Benner 1992), or DOM utilization (Amon and Benner 1996), or both (Cherrier *et al.* 1996).

Funka Bay is in the subarctic region, south-west of Hokkaido, Japan. It covers an area of ~2300 km^2, and has a maximum depth of ~100 m (Fig. 1). The spring phytoplankton bloom usually occurs every March or April (Odate 1992; Kudo and Matsunaga 1999), and nutrient concentrations (nitrate and silicate) in the euphotic layer are usually exhausted after the bloom (Kudo *et al.* 2000). Thermal stratification that occurs in summer restricts the nutrient supply from the deeper layer, and the euphotic layer becomes oligotrophic. At this time, dissolved oxygen (DO) concentrations below the thermocline decrease to suboxic

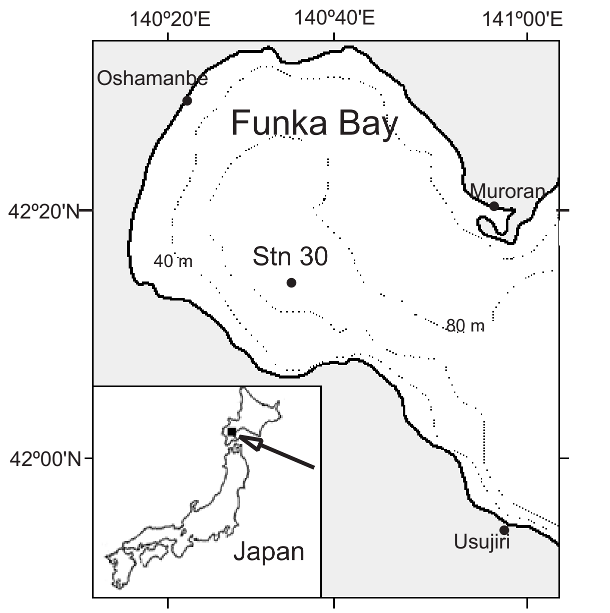

Fig. 1. Location of the Stn 30 sampling station (42°16.2′N,140°36.0′E) in Funka Bay, south-western Hokkaido, Japan. Broken lines, 40 m and 80 m isobaths.

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