Biochemical composition and the contributions of hydrolysable particulate organic matter in the Ross Sea, Antarctic Ocean

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Abstract

Water (<100 m) samples were collected from the Ross Sea (Antarctica) in late February to early March 2018, with the aim of investigating the spatial distribution of biochemical composition (proteins; PRT, carbohydrates; CHO, and lipids; LIP) and bioavailability of particulate organic matter (POM). Overall, the biochemical composition of POM was dominated by CHO, which accounted for 58.8% (SD = ± 12.8%) of total POM concentration, followed by PRT(21.0 ± 11.3%) and LIP (20.2 ± 9.7%). The particulated hydrolysable PRT (HPRT) ranged from below the detection limit 0 to 56.7 µg/L, hydrolysable CHO (HCHO) from 7.6 to 121.0 µg/L, and hydrolysable LIP (HLIP) from 7.0 to 86.6 µg/L, respectively. As a result, HPRT, HLIP, and HCHO accounted for 67.9%, 37.8%, and 64.6% of each compound, respectively. These results showed that PRT and CHO were largely used as sources of energy for higher trophic levels in the Ross Sea. .

1. Introduction

- Particulate organic matter (POM) as well as living and dead organisms, and refractory organic matter are included. The labile fractions of POM are characterized by activities of enzymes and their degradation provides insight into how actual POM is bioavailable to consumer organisms (Dell'Anno et al., 2000; Misic et al., 2017).
- Biochemical components of POM can be partitioned into fractions such as proteins (PRT), lipids (LIP), and carbohydrates (CHO) and reflect an assessment of the physiological state of phytoplankton in response to environmental conditions. Changes in biochemical composition determine quantity of resources available to higher trophic levels because each components have different calorie.
- Therefore, the purpose of this study, in order to better understanding potential changes in the Antarctic marine ecosystem, was (i) to investigate spatial distribution in quantitative and qualitative characteristics of POM, (ii) to estimate contribution of the lability of POM, and (iii) to evaluate potential role of the POM as energy source.

2. Materials and Methods

2.1. Biochemical composition of POM

Seawater sample obtained from 100m water depth went through a pre-combusted 25mm GF/F filter (pre-combusted at 450 °C, 4 hour). The fraction of PRT, CHO, and LIP were determined following the protocols of (Lowry et al., 1951; Dubois et al., 1956; Bligh and Dyer, 1959; Marsh and Weinstein, 1966). Concentrations of macromolecules were measured using a spectrophotometer (Labomed, Germany), which is determined by comparison to the standard curve with blank filters (procedural control filters, Whatman GF/F filter).

2.2. Enzyme-hydrolyzable experiments

Three enzymes were used in the enzyme-hydrolysable experiments: Proteinase K (Sigma-aldrich), β-glucosidase (Sigma-aldrich), and lipase (Sigma-aldrich). Based on several studies, Proteinase K, β-glucosidase, and lipase were chosen for the hydrolysis of the PRT, CHO, and, respectively LIP (Dell'Anno et al., 2000; Misic et al., 2017). The sample filters and blank filters were placed in enzyme solutions (100mg L^{-1} in 0.1 M sodium phosphate buffer) to react 2 hr (Proteinase K), 2 hr (β-glucosidase), and 30 min (lipase). After hydrolysis, each filters were rinsed with buffer and deionized water and processed for determinations of PRT, CHO, and LIP concentrations as described in section 2.1. The concentrations of the hydrolyzed macromolecular fraction were calculated by subtracting the total concentrations.

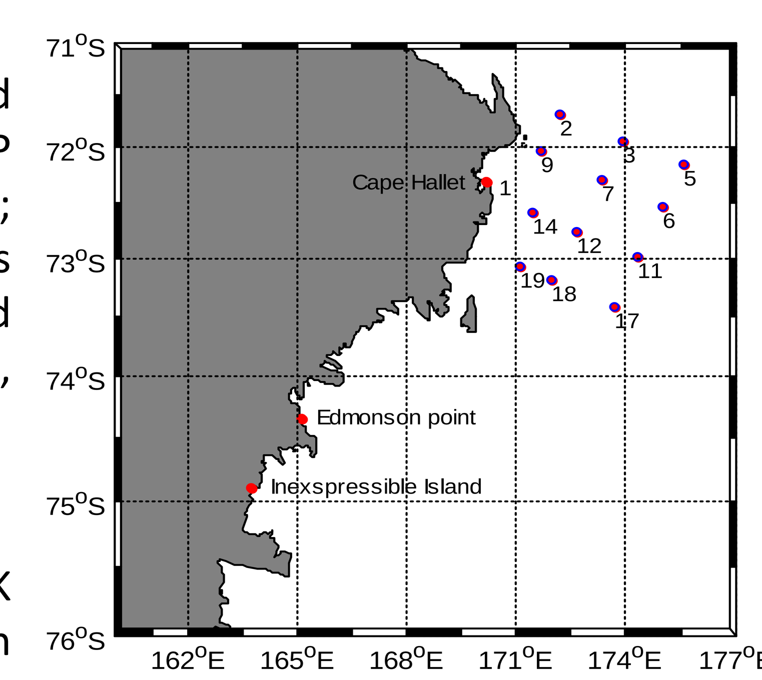

Fig. 1. Study area

3. Results and Discussion

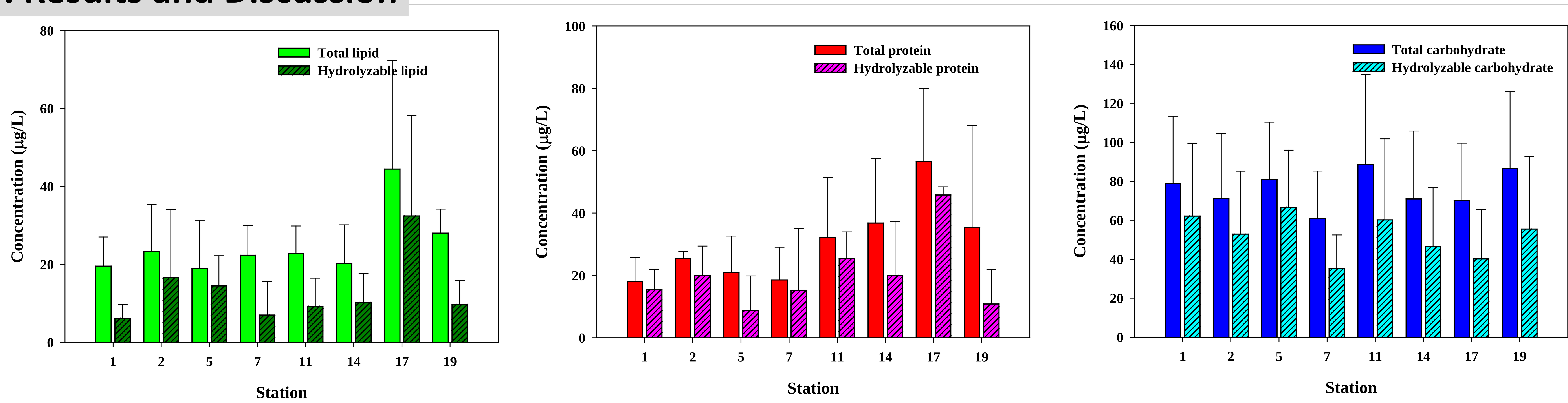

Fig. 2. Total and hydrolyzable lipids, proteins, and carbohydrates concentration of POM within 100m water depth.

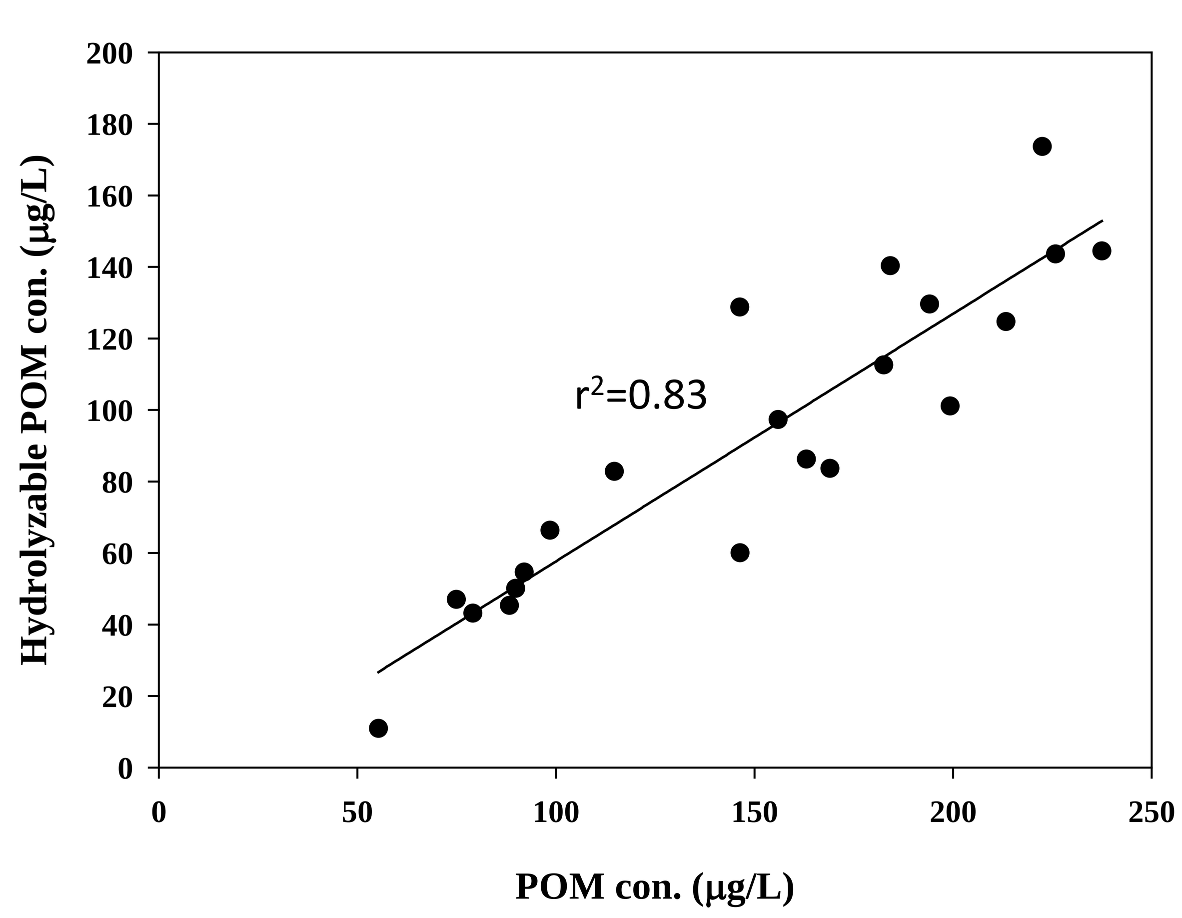

Fig. 3. Linear regression between POM and hydrolysable POM concentration in the Ross Sea.

- Absolute food material (POM) is the sum of LIP, PRT, and CHO concentrations, ranging from 41.7 to 237.5 µg/L with an average of 130.8 µg/L (SD = ± 51.8 µg/L) (Fig. 2). A strong positive linear relationship (r^2 = 0.83) was found between POM and hydrolysable POM concentration (Fig. 3). These results show that the positive effect of a large amount of POM is influenced on the quantity bioavailability of POM.
- In this study, the contribution of hydrolysable POM to POM (%; bioavailability of POM efficiency) ranged between 19.7% (100m at St. 19) and 88.0% (surface at St. 1) with an average of 59.6%. Overall, large contribution of the labile fraction of PRT (67.9%) and CHO (64.6%) have been observed in the Ross Sea.
- Our findings are contradictory to the conclusions of Handa and Tominaga (1969) and to results obtained by Dawson and Liebezeit (1982), Christian and Karl (1995), and Fabiano et al., (1995). These reports suggested that the cellular and proteinous amino acid were lost rapidly compared to extractable sugars and particulate CHO. Higher the C:N ratios of organic matter with increasing depth also reflect the preferential loss of nitrogen and proteinaceous matter during the organic matter degradation, which caused by bacteria for energy acquisition or biomass production (Christian and Karl, 1995; Fabiano et al., 1995; Handa and Tominaga, 1969).
- However, Fabiano and Pusceddu (1998) reported that about 40% particulate PRT remain unutilized in a pool due to relatively scarce microbial community in the Terra Nova Bay. Inherent structural difference in POM also might affect their enzymatically hydrolysis because structural CHO or complex CHO is more stable and resists degradation than those involved in storage (Middelburg, 2019). Taken together, different enzymatically hydrolysable efficiencies were result from a preferential loss of biochemical and contribution of microbial activity.

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