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The role of infaunal functional and species diversity in short-term response of contrasting benthic communities to an experimental food pulse

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ABSTRACT

Benthic communities play a major role in organic matter remineralization but the role played by macrofauna functional and taxonomic diversity remains elusive. To investigate this topic, we collected sediment cores from two different continental shelf locations near British Columbia, Canada, that differed in diversity to determine how the communities would respond to organic enrichment in the short term (~24 h). We added phytodetritus to half of the cores, measured benthic oxygen and nutrient fluxes in natural and enriched incubations, identified macrofauna, and calculated a suite of functional and taxonomic diversity indices. We found that benthic communities in Saanich Inlet (SI) and the Strait of Georgia East (SoGE) differed significantly in composition and that this difference corresponded to significant differences in benthic flux rates between sites. Multivariate analyses showed that the higher taxonomic (Simpson's diversity) and functional richness (FRic) observed in SoGE explained generally higher benthic flux rates at SoGE compared to SI. In enriched incubations, the higher species richness observed at SoGE explained most of the enhanced benthic flux rates measured in SoGE compared to SI. Our study also identified mean densities of detritivores and omnivores as primary predictors of the higher benthic flux rates measured in enriched incubations in SoGE compared to SI. These results suggest that detritivores and omnivores are the first functional groups of macrofaunal organisms to ingest fresh phytodetritus on the seafloor, and point to their primary importance in short-term remineralization of organic matter following phytoplankton bloom deposition on the seafloor. Our results further indicate that sediments with higher functional diversity may process organic matter and regenerate nutrients more quickly than lower diversity sediments, and that diversity loss may have negative consequences for ecosystem functioning of continental shelf sediments.

1. Introduction

Benthic communities play an important role in recycling organic matter (OM) that does not get remineralized in the water column and settles on the seafloor. In addition to direct ingestion of OM, feeding, bio-irrigation and bioturbation activities of infaunal organisms typically enhance microbial OM remineralization by oxygenating sediments and physically breaking down OM (Aller and Aller, 1998; Welsh, 2003). Organisms that live on and in sediments also experience different amounts of OM deposition seasonally and spatially, which is influenced by local variation in primary productivity and resulting particulate organic carbon (POC) flux to the seafloor (Jahnke, 1990). Previous work demonstrates rapid macrofaunal and bacterial population response to fresh OM deposition on the continental shelf and in the deep-sea (Moodley et al., 2005).

Most previous studies investigating the role of macrofauna on organic matter recycling manipulated species abundance and diversity in laboratory experiments (for example, see Mermillod-Blondin et al., 2005; Michaud et al., 2005). Although most reported a positive effect of diversity on OM recycling, other studies suggest that manipulative laboratory experiments may underestimate the contribution of biodiversity to ecosystem functions such as OM recycling (Duffy, 2009; Godbold, 2012). Therefore, other studies highlighted the need to investigate the role of macrofauna in organic matter remineralization following organic matter deposition in natural, mixed communities (Snelgrove et al., 2014; Welsh, 2003).

Interestingly, most enrichment experiments on the effects of fresh phytodetritus have focused on deep-sea benthic community respiration rates and followed the fate of this labile food source through different benthic compartments (Aberle and Witte, 2003; Levin et al., 1999; Sweetman and Witte, 2008; Witte et al., 2003). Using ^{13}C–labeled diatoms, these studies generally showed increased sediment community oxygen consumption (SCOC) rates and carbon remineralization following enrichment, and identified macrofauna as key players in food

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uptake. They also often attribute ingestion of ^{13}C–labeled phytodetritus to surface and sub-surface deposit feeders (Aberle and Witte, 2003; Levin et al., 1999; Sweetman and Witte, 2008; Witte et al., 2003). However, no research has specifically investigated the impact of fresh phytodetritus on oxygen and nutrient flux rates in benthic communities with contrasting diversity in order to investigate the effect of diversity on benthic flux rates and organic matter recycling, an important benthic ecosystem function (Giller et al., 2004).

In order to gain insight into the effect of benthic community diversity on responses to fresh phytodetritus input, we examined short-term changes in oxygen and nutrient flux rates in natural and enriched incubations at two contrasting sites that differed strongly in benthic community diversity. Low diversity characterizes Saanich Inlet (SI, Fig. 1) infauna (Belley and Snelgrove, 2016), likely because the large annual influx of OM in spring and fall results in severe hypoxia or anoxia and subsequent mass mortality of sessile animal species and displacement of motile species (Chu and Tunnicliffe, 2015). The adjacent Strait of Georgia (SoG, Fig. 1) site harbours a more diverse benthic community (Belley and Snelgrove, 2016) and, despite the absence of seasonal anoxia, deep-water renewal by neighbouring shelf waters may transport sporadically hypoxic bottom waters into SoG (Johannessen et al., 2014). More frequent and pronounced hypoxic events in the SoG in

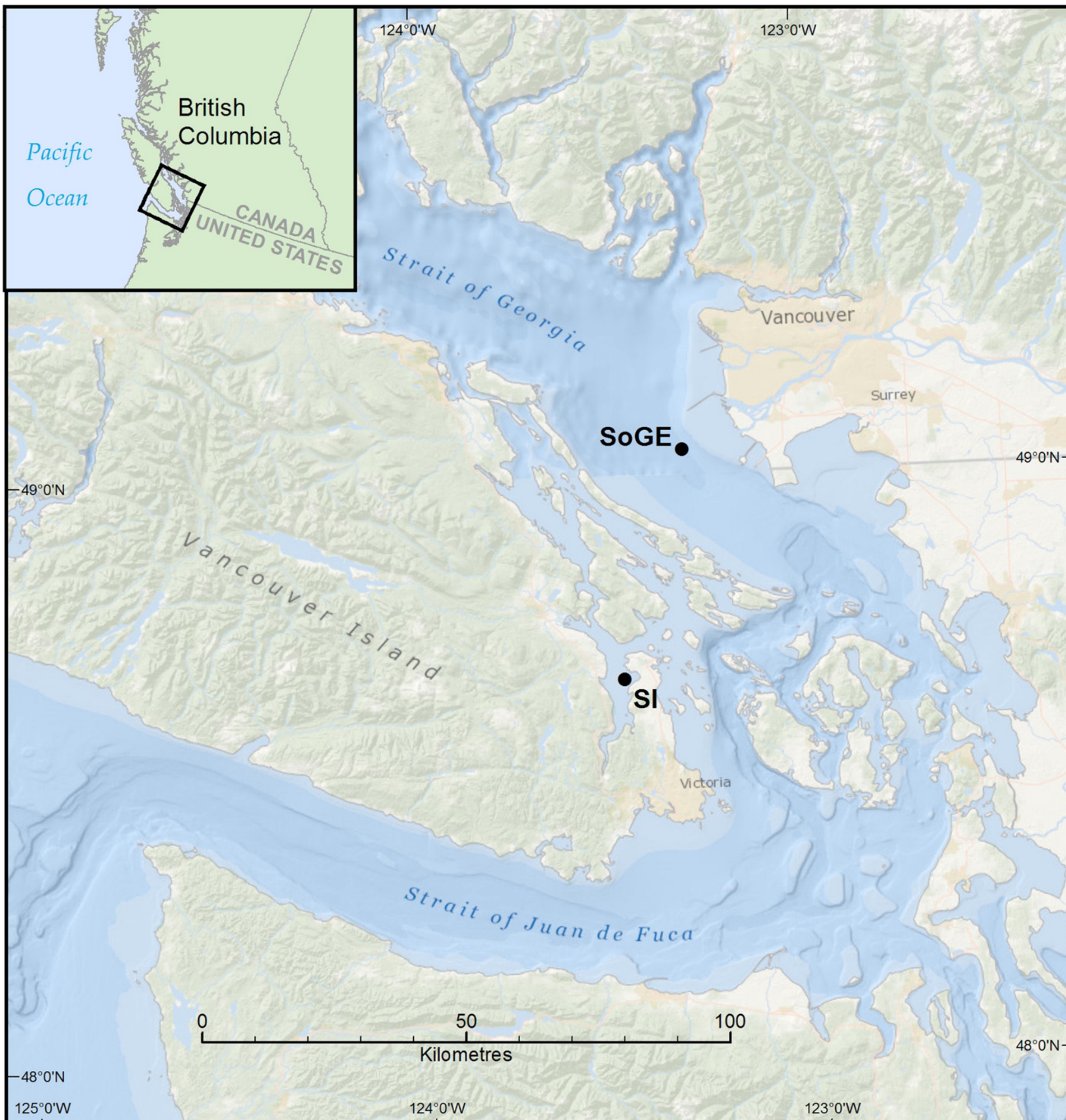

Fig. 1. Sampling locations in Saanich Inlet (SI, 97 m depth) and the Strait of Georgia (SoGE, 167 m depth) in September 2013.