Environmental Drivers of Benthic Community Structure and Function in Fjords of the West Antarctic Peninsula

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Abstract

The West Antarctic Peninsula (WAP) is a unique ecosystem in which harsh environmental conditions influence benthic community assembly processes from dispersal to the development of a complex community. The coastline of the WAP is lined with deep, glaciomarine fjords in which glacial processes affect stratification, sedimentation, and biological productivity which in turn affect the benthos. The environmental background and context of WAP fjords is provided in chapter I. The chapters that follow explore the roles of habitat heterogeneity, larval dispersal, and food availability as drivers of benthic community structure and function in WAP fjords. In chapter II, photographic surveys of WAP fjord and shelf habitats quantify the distribution of hard substrate in the form of glacial dropstones. The inclusion of this substrate type enhances the species richness of WAP benthos by 20% as well as the functional diversity by supporting an abundance of hard-substrate obligate fauna that are predominantly suspension feeders. Colonization patterns of dropstones are consistent with recruitment-limitation rather than by the availability of dropstones suggesting that dispersal processes constrain dropstone colonization. Chapter III explores patterns of larval dispersal and settlement of benthic organisms with varying life-history traits during the austral summer using coupled hydrodynamic and particle-tracking models. Results show that connectivity between neighboring fjords < 50 km apart is lacking for organisms producing larvae with demersal swimming behavior and short development times. > 98% of these larvae were retained within natal fjords indicating that self-recruitment processes are important for maintaining fjord populations. Larvae with long development times that lack swimming abilities were transported away from natal fjords, especially in surface layers (< 100 m) that were affected by episodic Katabatic winds. Connectivity to the broader WAP shelf was increased for these organisms with larval export from our study region reaching up to 39%. While chapters II and III explored the influence of environmental conditions on spatial patterns of community structure, chapter IV investigated the influence of short-term changes in food availability on the function of benthic organisms within a glaciomarine fjord of the WAP. Benthic time-lapse photography was used to quantify the accumulation and utilization of phytodetritus by detritivores. Phytodetritus arrived in a singular pulse in summer which overwhelmed benthic detritivores and developed a sediment food bank storing labile organic matter throughout the winter. Phytodetritus was consumed rapidly by

detritivores which fed throughout the winter months when overlying productivity was absent. The formation of the sediment food bank decoupled detritivore feeding from variability in surface productivity and aids in maintaining high abundances of large detritivores inside the fjord. As fjord productivity is regularly observed to be greater than that of the outer WAP shelf, it is likely that these results are representative of most WAP fjords highlighting the importance of detritivores in the regional carbon cycle. Finally, chapter V summarizes the main findings of this dissertation research, discusses these results in the context of future climatic changes on the WAP and identifies outstanding research questions stimulated from this work. This dissertation provides the first focused study of dropstone communities in the Antarctic, the first modelling study of benthic larval dispersal from WAP fjords and presents a methodology for quantifying seafloor phytodetritus using oblique time-lapse imagery of the seafloor.