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Comparison of bryozoan assemblages from two contrasting Arctic shelf regions

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Abstract

The structure of bryozoan assemblages from two Arctic regions (East Greenland and West Spitsbergen shelf) was compared. Both areas are located at the same latitude and the samples were taken from similar depths; however, the regions differed in water temperature and oceanography. East Greenland, which has lower mean annual water temperatures, was found to be one third richer in taxa (86 species) than West Spitsbergen (59 species). Diversity (Shannon–Wiener index – H') and abundance were also higher on average in East Greenland (e.g. $H' = 2.49$) than West Spitsbergen (e.g. $H' = 2.12$). However for species richness, diversity and abundance there were no significant statistical differences between means (ANOVA) from the two regions. In spite of these similarities the investigated assemblages differed to a large extent in both species composition and dominance structure. There were 55 species that occurred only in East Greenland and 28 species that were present only in West Spitsbergen. There was higher proportion of species with an Arctic distribution in East Greenland (46%) than in West Spitsbergen (24%). Observed dissimilarities were concluded to be due to different hydrological conditions between the two regions.

Keywords: biodiversity; water masses; Bryozoa; Arctic; East Greenland; West Spitsbergen

1. Introduction

Arctic hydrology is influenced by a complex of water masses of different origin, thus environmental conditions across the Arctic marine system are not homogenous. Usually these water masses differ in seawater temperature, which affects annual longevity of ice cover, glacier retreat, freshwater water inflow and sedimentation into the marine ecosystem (e.g. Peterson et al., 2002). The shallow Arctic shelf is influenced to a large extent by the inflow of waters both from deeper parts of the oceans and by terrigenous waters from the continent. Thus these areas are controlled by ongoing changes in both the terrestrial and marine environment. Differences in physical conditions among Arctic localities are mirrored in the community structure of benthic faunal assemblages. For instance, it was found that fish stocks of the Barents Sea follow fluctuations in seawater temperatures, with higher seawater temperatures favouring survival of the critical early life stages of the fish (Ottersen et al., 2006). Analysis of annual photographs at a permanent rocky bottom station on West Spitsbergen over a period of more than 20 years revealed that diversity of the benthic biota is strongly linked to sea water temperature – the higher the sea water temperature the higher the biodiversity (Beuchel et al., 2006). On the other hand, there are examples where the presence of warm water masses have an opposite effect on parameters like richness or biodiversity of Arctic biota. An investigation of soft-bottom benthos at two Arctic locations differing in seawater temperature has shown that the "warmer site" had lower species richness and biodiversity than a "cooler" site (Wlodarska-Kowalczuk and Weslawski, 2001).

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Several studies indicate that aquatic sessile organisms, both individually and collectively as assemblages, are good indicators of environmental conditions or long-term ecosystem changes (Kröncke, 1995; Wlodarska-Kowalczuk and Weslawski, 2001; Beuchel et al., 2006). In the Arctic, aquatic sessile colonial invertebrates are one of the most diverse and abundant groups among rocky bottom organisms (Gulliksen et al., 1999; Kuklinski and Bader, 2007). Their potential sensitivity to physical parameters as well as high abundance make them good candidates for comparative studies of locations differing in environmental conditions. This study focuses on bryozoan faunal composition and assemblage structure on rocky substrates from two contrasting Arctic regions that differ in hydrological conditions.

We conducted our investigation in two regions: East Greenland and West Spitsbergen shelf. Both have conspicuous oceanographic features. The East Greenland location is the largest and most northernly Arctic Polynya (usually an open-water region within an otherwise ice-covered sea) influenced by the cold East Greenland Current. Thus this region can be considered as ‘‘cold Arctic’’, whereas West Spitsbergen is influenced by the Gulf Stream and has a milder climate compared to other areas of similar latitude, and may be considered as ‘‘warmer Arctic’’ (Gammelsrod and Rudels, 1983; Loeng, 1991; Bignami and Hopkins, 1997; Ritzrau, 1997). These regions provide a good model systems for testing hypotheses concerning the influence of different water mass properties on the Arctic biota.

The aim of the study was to investigate faunal structure and differences between assemblages of bryozoans from two sites at similar latitude but differing in seawater temperature. We predict that these assemblages will differ in species composition, richness, diversity and abundance. We also predict that the proportion of species of temperate origin or Arctic species that range into warmer seas will be higher in ‘‘warm Arctic’’ site. Our hypotheses are based on the assumption that differences in seawater temperature or sea ice cover longevity between the sites should be mirrored in dissimilarities among assemblage structure.

2. Materials and methods

2.1. Study area

Two regions in Greenland Sea were selected: East Greenland and West Spitsbergen shelf (Fig. 1). Both are at the same latitude (79°N), and samples were taken from approximately the same range of depths (East Greenland 75–233 m depth, West Spitsbergen 122–260 m). The study sites differ in hydrology, distance from the land and size of the shelf. The East Greenland site is strongly influenced by the East Greenland Current, which originates in the Arctic Ocean. The salinity regime varies from 32.3 to 35 psu, while the temperature range is from −1.7 °C to 3 °C (Bignami and Hopkins, 1997). The area is characterised by ice-free zones or loose ice-cover throughout the year, although it is greatly reduced in size during the winter (Minnett et al., 1997). The West Spitsbergen region is influenced mainly by the West Spitsbergen Current, a branch of the warm (4 °C) and highly saline (35 psu) Norwegian Current (Loeng, 1991). The area is usually ice-free throughout the year (Svendsen et al., 2002). Owing to the vicinity of land and glaciers, the West Spitsbergen site is influenced by freshwater discharge during the summer which causes strong water mass stratification and high concentrations of suspended sediment (Svendsen et al., 2002). The East Greenland shelf is four times wider (~400 km) than the West Spitsbergen shelf (~100 km). The sea bottom at both regions consists of fine clastic sediment with dropstones (ice rafted debris) of variable size (Piepenburg, 1988).

2.2. Protocol

Assemblage comparisons require the use of strictly standardised methods and sample-processing and only similar habitats should be compared (Gray, 2001). Stones offer a uniform substrate that is an ideal model habitat for such comparisons. Therefore, we focus only on bryozoans inhabiting dropstones. Samples of rocks were taken during cruise ANTXVI/2 of the R/V Polarstern (East Greenland) and R/Y Oceania as well as the R/V Jan Mayen (West Spitsbergen) in August 2000 (Fig. 1). Samples were collected by means of dredges. From each region (East Greenland and West Spitsbergen) 100 rocks supporting bryozoans were collected haphazardly. Number of rocks collected at each station is indicated on Fig. 1. Surface areas and faunal percentage coverage of stones were estimated using an inelastic net marked in a grid of 1 cm^2. All bryozoans were determined to the lowest taxonomic level possible and counted. Each colony was considered as one individual. All taxonomic identities were determined using Kluge's (1975) monograph of bryozoans. Bryozoan species were classified biogeographically into three categories according to Gontar and Denisenko (1989): Arctic, Arctic-boreal and boreal. The number of species in each biogeographical category was expressed as a percentage value for each location.

Abundance was calculated as the number of colonies per square metre of rock surface area. Diversity measures were calculated using the PRIMER software package (Clarke and Gorley, 2001), including species richness and Shannon–Wiener H' diversity index (log base e). All data (species richness, Shannon–Wiener H' diversity and abundance) were subjected to ANOVA with region as a spatial factor.

The relative similarity of site assemblages was compared and displayed using PRIMER software package following fourth, square root transformed as well as untransformed data. Bray–Curtis similarity measures were calculated (Bray and Curtis, 1957). The inter relationship between samples was mapped using the ordination technique, non-metric, multidimensional scaling (nMDS).

One-way analyses of similarities (ANOSIM; Clarke and Green, 1988) were used to test *a priori* differences in assemblages with region as a spatial factor. ANOSIM uses the test statistic R, which is calculated using average rank similarities among pairs of replicates within each of two groups (e.g. East