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Short Note
Is Antarctic benthic biomass really higher than elsewhere?

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Introduction

There are two common views of Antarctic macrozoobenthic biomass among benthic ecologists: (i) in shallow water biomass is comparatively low due to ice impact (abrasion by icebergs and floating sea ice, anchor ice), and (ii) at least in shelf areas biomass is outstandingly high. These views originate from several published comparisons of Antarctic with Arctic data (George 1977, Knox & Lowry 1977), or of Antarctic data with data from non-polar regions (White 1984, Dayton 1990, Dayton *et al.* 1974, Brey & Clarke 1993, Arntz *et al.* 1994). A valid statistical evaluation of this topic, however, is still lacking. Here we analyse benthic biomass data collected from the literature to answer three questions: (i) is there any significant difference between Antarctic and non-Antarctic benthic biomass; (ii) how is this difference related to water depth; and (iii) is this difference due to particular taxa or feeding guilds?

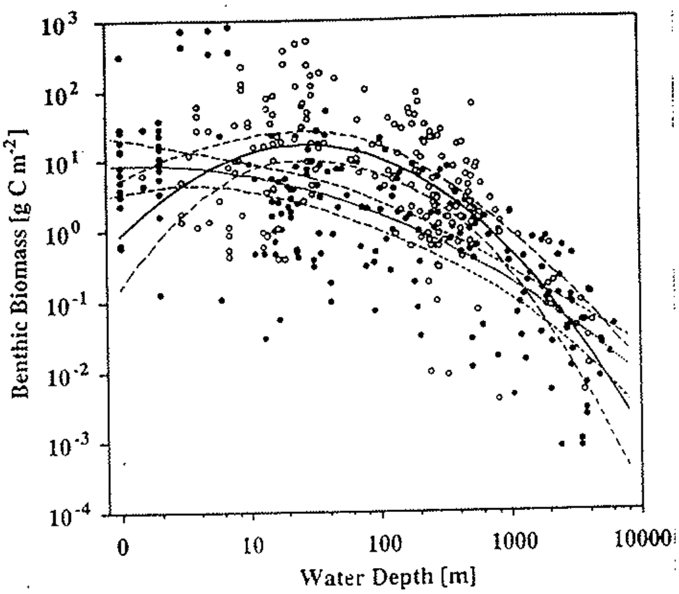

Fig. 1. Distribution of macrobenthic community biomass ($g\ C_{org}\ m^{-2}$) with water depth (m) in Antarctic (o) as well as non-Antarctic regions (●). Zero depth indicates intertidal data. Superimposed are the 2nd order polynomial functions fitted to the data (X = log(depth + 1); Y = log(biomass)) and the corresponding 99% confidence intervals.

Antarctic: $Y = -0.054 + 1.787 * X - 0.622 * X^2$; $r^2 = 0.411$; $n = 196$; solid line

Non-Antarctic: $Y = 0.937 + 0.039 * X - 0.199 * X^2$; $r^2 = 0.523$; $n = 211$; stippled line

Methods

The "Antarctic" is taken as those regions south of 60°S. The non-Antarctic data are from regions between 68°N–55°S, thus excluding the Arctic. Data from published papers were converted to $g\ C_{org}\ m^{-2}$, using conversion factors for major taxonomic groups published in Cummins & Wuycheck (1971), Dayton *et al.* (1974), Atkinson & Wacasey (1976), Steimle & Terranova (1985), Rumohr *et al.* (1987), Wacasey & Atkinson (1987), Walker *et al.* (1987), Brey *et al.* (1988), Dauvin & Joncourt (1989), and Barthel (1995). There were 196 Antarctic biomass data (60°–78°S, water depth: 0.5–4293 m) and 211 non-Antarctic data (68°N–55°S, water depth: 0–6229 m) in the analysis. We fitted 2nd order polynomials to the log(depth + 1) – log(biomass) data of both regions and computed the corresponding 99% confidence intervals. Non-overlap of the 99% confidence intervals of both functions were interpreted as indicating a significant difference in biomass at this particular depth.

Results and discussion

Data collection and treatment

Figure 1 shows these data with superimposed best fitting polynomials and 99% confidence intervals, and indicates significantly higher benthic biomass in the Antarctic region between *c.* 10–1000 m water depth. Our data include all information available on Antarctic benthic biomass, but a non-randomly collected subset of non-Antarctic biomass data. Moreover, both sets include data based on a variety of sampling techniques and sampling units of different sizes. To compensate for the data variability introduced by methodical differences, we tried to maximise the number of data and data sources included in our analysis. The low number of Antarctic data below 1200 m depth causes a lack of statistical power and makes it difficult to detect any differences in this depth range.

Effects of water depth

Between the intertidal and 10 m water depth there are no differences in biomass between the Antarctic and the non-Antarctic. Hence, the asumption of Dayton *et al.* (1974), White (1984) and others that enhanced physical stress by ice impact prevents the shallow water benthos from building up high standing stocks may be true compared to deeper Antarctic waters (0–100 m depth range), but not in comparison to non-Antarctic shallow water sites. Intertidal and shallow subtidal areas can be considered as stressful environments (e.g. wave exposure, temperature) for marine organisms world wide (Earll & Erwin 1983, Levinton 1982), and the stress of ice impact is not outstandingly high compared to other potential sources of physical stress.

From the shallow subtidal down to the upper continental slope (10–1000 m) Antarctic macrobenthic biomass is significantly higher. As discussed by Brey & Clarke (1993), the combination of high (up to 130 g C m^{-2} y^{-1}, Schalk *et al.* 1993) but seasonally strongly oscillating food input and low ambient temperature (≤ 0°C) may be the key to the understanding of this phenomenon.

On the lower slope and in the deep sea (below 1000 m), Antarctic and non-Antarctic biomass figures converge and decrease distinctly with increasing depth. Similar sedimentation rates at this depth (cf. Suess 1980, Schalk *et al.* 1993) are likely to lead to similar benthic biomass values, whereas the temperature difference between Antarctic and non-Antarctic waters (2–4°C, see Gage & Tyler 1991) seems to have no significant effect.

Contribution of taxonomic groups

The heterogenity of the literature on benthic biomass allows only for qualitative statements on the large scale distribution of biomass among taxa. A comparison of Antarctic data (see biomass data sources) with several non-Antarctic locations such as Georges Bank (Steimle 1987, Theroux & Grosstein 1987), the Magellan Region (Gerdes unpublished), the North Sea (De Wilde *et al.* 1986), New Zealand (Probert & Anderson 1986) and tropical estuaries (Alongi 1990) indicates that the Antarctic benthos is characterised mainly by an extraordinary high biomass of sponges, accompanied by uncommonly high contributions of echinoderms, tunicates and bryozoans to total benthic biomass. These groups seem to have adapted best to the particular environmental conditions of the Antarctic shelf and slope regions.

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The biomass data source references are available on request from the first author by email (tbrey@awi-bremerhaven.de) or by mail.