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SHORT NOTE

Julian Gutt · Andreas Starmans

Patchiness of the megabenthos at small scales: ecological conclusions by examples from polar shelves

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Abstract With two exceptions, no general patterns of patchiness of the megabenthos were found on the Antarctic shelf and off northeast Greenland. Underwater videos were used as a sampling method and Morisita's Index of Dispersion for statistical analysis. A gradient from randomness to patchiness occurred for most taxa, whereas the pattern of asteroids could not be distinguished from randomness. In the Antarctic, the totals of other mobile animals were less aggregated than for sessile taxa. The findings are interpreted as a result of ecological complexity within species assemblages.

Introduction

Animals are rarely uniformly dispersed in nature (Pielou 1977; Begon et al. 1996), a fact that is obvious on land. However, on the sea floor, traditional sampling by towed sampling gear integrates data over long distances, and the area covered by cores is too small to provide results about megabenthic patchiness. As a consequence, simple conclusions that demand information about patchiness, e.g. on species numbers or biological interactions within a community, can only be drawn on a hypothetical level.

One aim of this study was to provide a basis for specifying the reliability of quantitative surveys in megabenthic polar communities at the approximate spatial scale sampled by traditional gear. A second reason was an attempt to use dispersion patterns for conclusions on ecological demands and behaviour of specific taxa within communities. Within ecosystems, at large spatial scales, differences in communities are mainly the result of differences in the environment and long-term colonization, described for high latitudes, for example, by Curtis (1975), Kirkwood and Burton (1988), Dayton (1990), Faranda et al. (2000), and Gutt (2000) and, for the deep-sea, by Rice and Lambshead (1992). Underwater videos provide a spatial resolution that allows focus on patterns within megafaunal species assemblages. It is assumed that the driving forces of structures at this small spatial scale will differ from those relevant at larger scales. At small scales, these processes may include ecological demands, inter- and intraspecific interactions and disturbances, as well as behavioural reaction (Legendre and Legendre 1998).

J. Gutt (✉) · A. Starmans
Alfred Wegener Institute, Columbusstraße,
27568 , Bremerhaven, Germany
E-mail: jgutt@awi-bremerhaven.de
Tel.: +49-471-48311333
Fax: +49-471-48311149

Materials and methods

Sampling was carried out during R/V Polarstern expeditions ANT VI/3, southeastern Weddell Sea (12 stns.), 1988 (Fütterer 1988), ANT XI/3, Bellingshausen and Amundsen Seas (17 stns.), 1994 (Miller and Grobe 1996) and ARK IX/2-3, Northeast Greenland (25 stns.), 1993 (Hirche and Kattner 1994). Stations comprised between 60 and 90 min observations of the sea floor using a Remotely Operated Vehicle (ROV). Relatively straight video-strips were achieved by leaving the vehicle suspended from the drifting ship. They had an average length of 1 km and width of 50 cm indicated by two parallel laser beams acting as a scale on the image. The optical resolution of the video-camera permitted all organisms >1 cm to be counted. In addition to the videos, photographs were taken by the ROV as an aid to identifying the taxa present. A total of 68 taxa were identified for the Antarctic and 42 for the Arctic.

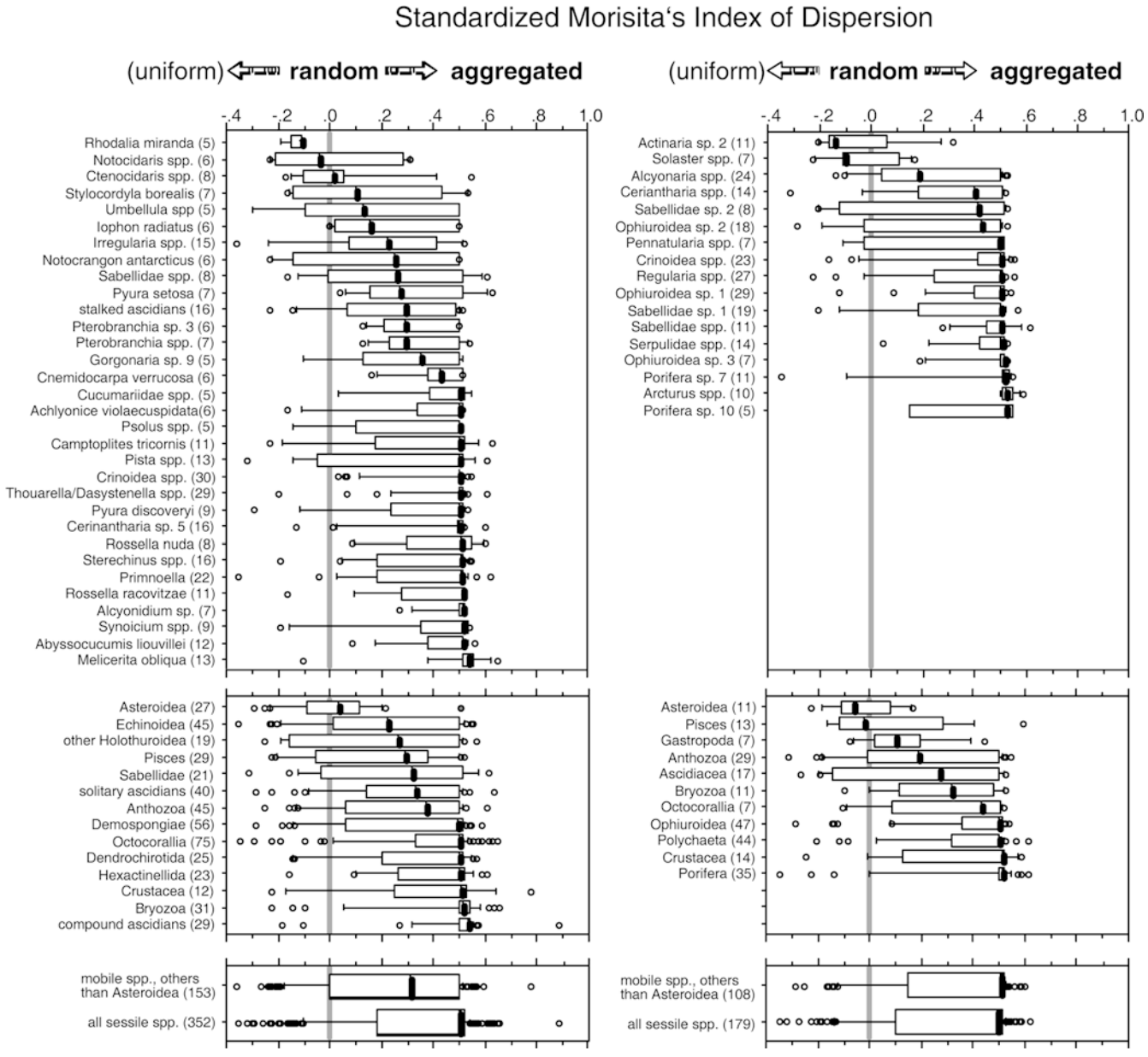
Standardized Morisita's Index of Dispersion (Krebs 1999) was calculated because values between -1 and $+1$ are statistically independent of population density and sample size (Myers 1978). Abundances were counted from video-images in strips approximately 10 m long. Due to variations in the distance of the ROV to the bottom, these varied in size with a mean of 3.6 $m^2 \pm 1.4$ (SD) between stations. Under optimum conditions, these 10-m sections were consecutive; however, they were reduced to those of the same size within a station, without pitch roll and of appropriate optical quality. Numbers of sections varied between 11 and 151 per station. All taxa present at ≥10% of the 10-m sections within a station were considered, resulting in 532 data for the Antarctic and 296 for the Arctic. To exclude undesired bias of the results, variations in size of

the 10-m sections (area) and samples (no. of sections per station) were checked for significant correlation with patchiness results. Of the calculations, for all taxa, a positive correlation was found only in four exceptional cases, exclusively from the Arctic.

Results

The most obvious result is a broad range of dispersion patterns within both taxa close to the species level and higher systematic groups. Approximately 50% of the analysed cases showed evidence of patchiness; the other 50% was randomly dispersed (Fig. 1). No single taxon or group was uniformly dispersed. A small proportion of taxa had low medians, e.g. Antarctic echinoids, indicating a random dispersion. However, this specific result does not reflect a general tendency within higher systematic groups. In both polar areas, asteroids had the lowest medians and, almost exclusively, values in the range of random dispersion; thus, they do not follow the general tendency of a broad range of values. The difference between all other mobile and sessile animals was significant only in the Antarctic. No differences were found between all data merged within the Antarctic and those from the Arctic (Mann-Whitney, $P \leq 0.05$).

Fig. 1 Small-scale patchiness/randomness of Antarctic and Arctic megabenthos referring to 5 m^2. Box plots of Standardized Morisita's Index of Dispersion for species and small taxonomic groups (*upper*), higher taxa (*centre*) and mobile versus sessile animals (*lower*). Numbers in *parentheses* indicate sample size (= no. of data sets comprising different species from different stations). Box plots show: median (*vertical line* in the *box*), 25 and 75% percentiles (*left* and *right* margins of the box), 10 and 90% percentiles (*left* and *right* end of the *horizontal bars*) and outliers (*circles* outside the range between 10 and 90% percentiles)



Discussion

In general, uniform or patchy dispersion of animals is generated by biological or environmental forces and is scale dependent. For the polar megabenthos, factors leading to uniform patterns, such as territorial behaviour, related to an optimum use of space do not exist or they are superimposed by factors that cause aggregation, e.g. by good feeding conditions or fragmentation, e.g. by iceberg scouring (Gutt 2000). Randomness, which described 50% of the results, is just another word for unpredictability, in the context of this study, of the conditions leading to a specific pattern. In most taxa and groups, we found both this unpredictability and patchiness. Obviously, ecological mechanisms that lead to patchiness are sometimes effective and sometimes not. Such a variation can be found within taxa or between stations and no general trends related to water depth or between both polar areas were detectable. We conclude that the ecological factors relevant at a spatial scale of 10 m are complex in their temporal and spatial performance. The more even abundances of asteroids and other echinoderms may indicate that they are more affected by large-scale conditions, which are relatively homogenous at the small spatial scale. This might be a main reason why asteroids contribute well in discriminating species assemblages (Piepenburg et al. 1997; Gutt 2000). In contrast sessile animals, especially slow-growing sponges, may integrate processes over a period of maybe hundreds of years. These can be superimposed by specific historic short-term events, e.g. in recruitment or mortality, which are unknown but the biological long-term effects are still obvious (for example, see Gutt 2001; Bolam and Fernandes 2002). Consequently, these animals have an uneven occurrence at smaller (this study) and larger scales (Gutt and Koltun 1995). It is known that abundant animals in the Antarctic tend to a higher degree of patchiness if they are smaller in size (Teixidó et al. 2002). Such a relationship, however, seems to be unlikely in our study because the Standardized Morisita's Index is independent of the population size. In addition, obvious patchiness was found in the Antarctic for the largest species with relatively low abundance, the glass-sponge *Rossella nuda*, as well as Demospongiae, and a random pattern for the relatively small and mobile pencil sea-urchins *Notocidaris* spp. and *Ctenocidaris* spp., as well as the shrimp *Notocrangon antarcticus*.

The conclusion for the applied aspect is simple. It is to assume that within defined communities, a homogenous environment and, as a consequence, a homogenous dispersion of the fauna exist. Before conclusions can be drawn, e.g. in biodiversity studies or concerning recommendations for nature conservation, the appropriate sample size must be checked.

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