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Biodiversity–ecosystem functioning relationships in long-term time series and palaeoecological records: deep sea as a test bed

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The link between biodiversity and ecosystem functioning (BEF) over long temporal scales is poorly understood. Here, we investigate biological monitoring and palaeoecological records on decadal, centennial and millennial time scales from a BEF framework by using deep sea, soft-sediment environments as a test bed. Results generally show positive BEF relationships, in agreement with BEF studies based on present-day spatial analyses and short-term manipulative experiments. However, the deep-sea BEF relationship is much noisier across longer time scales compared with modern observational studies. We also demonstrate with palaeoecological time-series data that a larger species pool does not enhance ecosystem stability through time, whereas higher abundance as an indicator of higher ecosystem functioning may enhance ecosystem stability. These results suggest that BEF relationships are potentially time scale-dependent. Environmental impacts on biodiversity and ecosystem functioning may be much stronger than biodiversity impacts on ecosystem functioning at long, decadal–millennial, time scales. Longer time scale perspectives, including palaeoecological and ecosystem monitoring data, are critical for predicting future BEF relationships on a rapidly changing planet.

1. Introduction

The relationship between biodiversity and ecosystem functioning (BEF) [1] has been a central topic of ecology since the 1990s [2,3]. A priority for ecosystem-based management, particularly in the context of global climate change and environmental degradation, is to understand how changes in species number and composition influence ecosystem functioning. Our understanding of various aspects of BEF relationships remains insufficient (see ref. [1] and other chapters [4–14] of this special volume), especially in marine systems, in spite of the growing body of information from experimental manipulations, modelling and observations.

Long-term BEF relationships relevant to the time scales of human-induced global climate change (e.g. decadal, centennial and millennial time scales) are a crucial but understudied field. Many BEF studies are based on short-term manipulative experiments and/or static spatial data [15–19]. Recent studies indicated