Does biological diversity matter for the stability of marine communities?

Martin Wahl, Marine Ecology - Experimental Ecology

Species are being irreversibly lost at an unprecedented pace. Will this de-stabilize communities, i.e. make them more vulnerable to stress and global change? In a global-scale approach involving more than 500 benthic communities in 8 biogeographic regions we show that species richness stabilizes communities when functional diversity is low, but tends to destabilize communities when functional richness is high. Given the decrease of functional richness in benthic hard bottom communities from the tropics towards the poles, we expect a more severe impact of species loss at higher latitudes.

A variety of metrics have been used when assessing "biodiversity". Species richness is certainly the most commonly used metric but also one of the most controversial ones. Thus, despite intense biodiversity research over the past decades, the role of species richness for the performance and stability of communities is still highly controversial. Recent reviews have shown that richness may stabilize or destabilize communities, and enhance or decrease their susceptibility to abiotic stress or biotic invasions (Balvanera et al., 2006, Romanuk et al., 2009, Valdivia & Molis, 2009).

Likely causes for the contradictory findings about the role of diversity are the use of different diversity metrics, differences in the biological and geographical properties of the systems investigated, in the pressures applied and responses measured, in the number of trophic levels considered, and in the duration of the experiments (Wahl et al., 2011). To avoid the weaknesses of previous studies we decided to work on "standardized" (same size, same age) natural communities, expose them to a natural environmental shift, allow sufficient time for a community level response (compositional stability), assess two important aspects of diversity simultaneously (species richness and functional diversity), and replicate the experiments at an unprecedented scale (500 communities in 8 biogeographic regions world-wide, Fig. 1).

Shortly, communities of sessile invertebrates and algae (Fig. 2) which had assembled on artificial substrata were transplanted between two moderately different sites within each region simulating environmental shift. As a response to this pressure, some species decreased, others increased in abundance, and new species invaded the community. The rate of this re-organization was used as a measure for the structural instability of communities under stress.

Fig. 1: The biogeographic regions covered in this investigation were (1) South East Pacific (Chile), (2) South West Atlantic (Brazil), (3) North Sea (England), (4) Baltic Sea (Finland), (5) West Pacific (Malaysia), (6) North West Pacific (Japan), (7) South West Pacific (New Zealand) , and (8) Tasman Sea (Australia).

The substantial effort invested into this study was rewarded by a consistent and interesting response pattern which explains a major part of the past controversy. Briefly, (i) at a global scale, more diverse ecosystems are not more stable at the community level than less diverse regions; at the regional scale (ii) functional diversity has important indirect effects on stability while (iii) species richness has important direct effects which, however, may be stabilizing or de-stabilizing. (Functional diversity in this context is defined as the number of "ecologically different" groups in the communities, i.e. species which differ in regard to body size, growth form, feeding type or coloniality, each of which represents

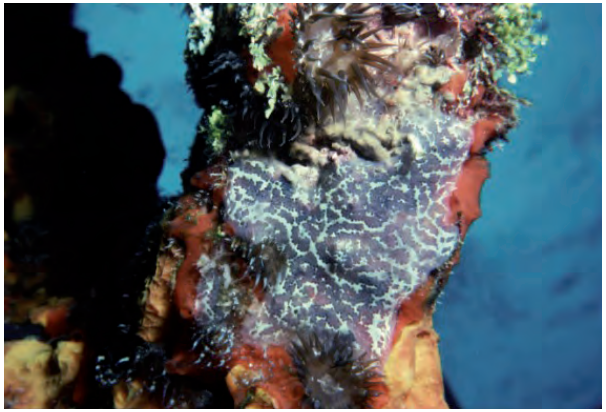

Fig. 2: Examples for tropical (A) and temperate (B) hardbottom communities.

a compound trait including other properties such as longevity or mode of reproduction.)

Community stability increased with species richness when functional diversity was low, but tended to decrease with species richness when functional diversity was high (Fig. 3). For a better understanding let us look at the two extremes of this gradient: Many

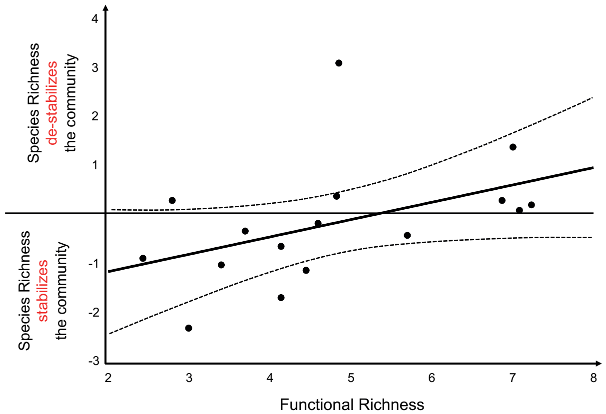

Fig. 3: Gradual change of the species diversity-stability–relationship from communities with low functional richness to communities with high functional richness. Values on the y-axis give the slope of the relationship between structural change and species richness. When values are negative, the rate of change driven by mortality and invasions decreases with species richness, i.e. structural stability increases with species richness.

species in communities with few functional groups leads to high functional redundancy: given ecological functions are represented by several species. Few species in communities with many functional groups leads to high complementarity: most species differ from each other ecologically. The two drivers of the re-organization process were mortality and bioinvasion. High functional diversity is considered an insurance against invasions because the invader is unlikely to find an unoccupied niche. Consequently, high redundancy in communities with reduced functional diversity warrants that the (few) functional groups are preserved even when single species are lost. At high functional diversity this important role of species richness is less crucial.

Our data show further that communities are functionally richer at low latitudes. Thus, the ongoing loss of species may have more severe consequences for community stability in temperate or polar regions than in tropical regions.

References

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