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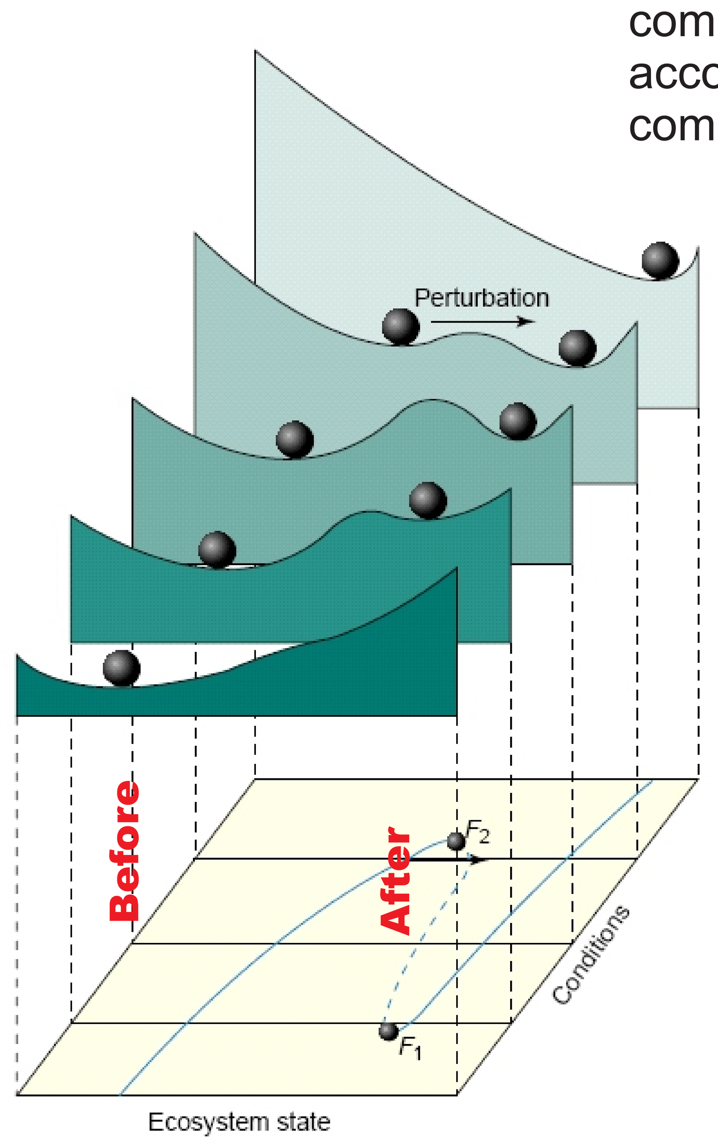
Stability and resilience in marine communities confronting fisheries disturbances: an allometric approach

Paúl Gómez-Canchong[a,b] , Renato A. Quiñones[b,c]

a COPAS Sur-Austral, Centro de Investigación Oceanográfica en el Pacífico Sur-oriental, Universidad de Concepción, P.O. Box 160-C, Concepción, Chile
b Departamento de Oceanografía, Universidad de Concepción, P.O. Box 160-C, Concepción, Chile
c Interdisciplinary Center for Aquaculture Research (INCAR), Universidad de Concepción, P.O. Box 160-C, Concepción, Chile

*corresponding author: paulgomez@udec.cl

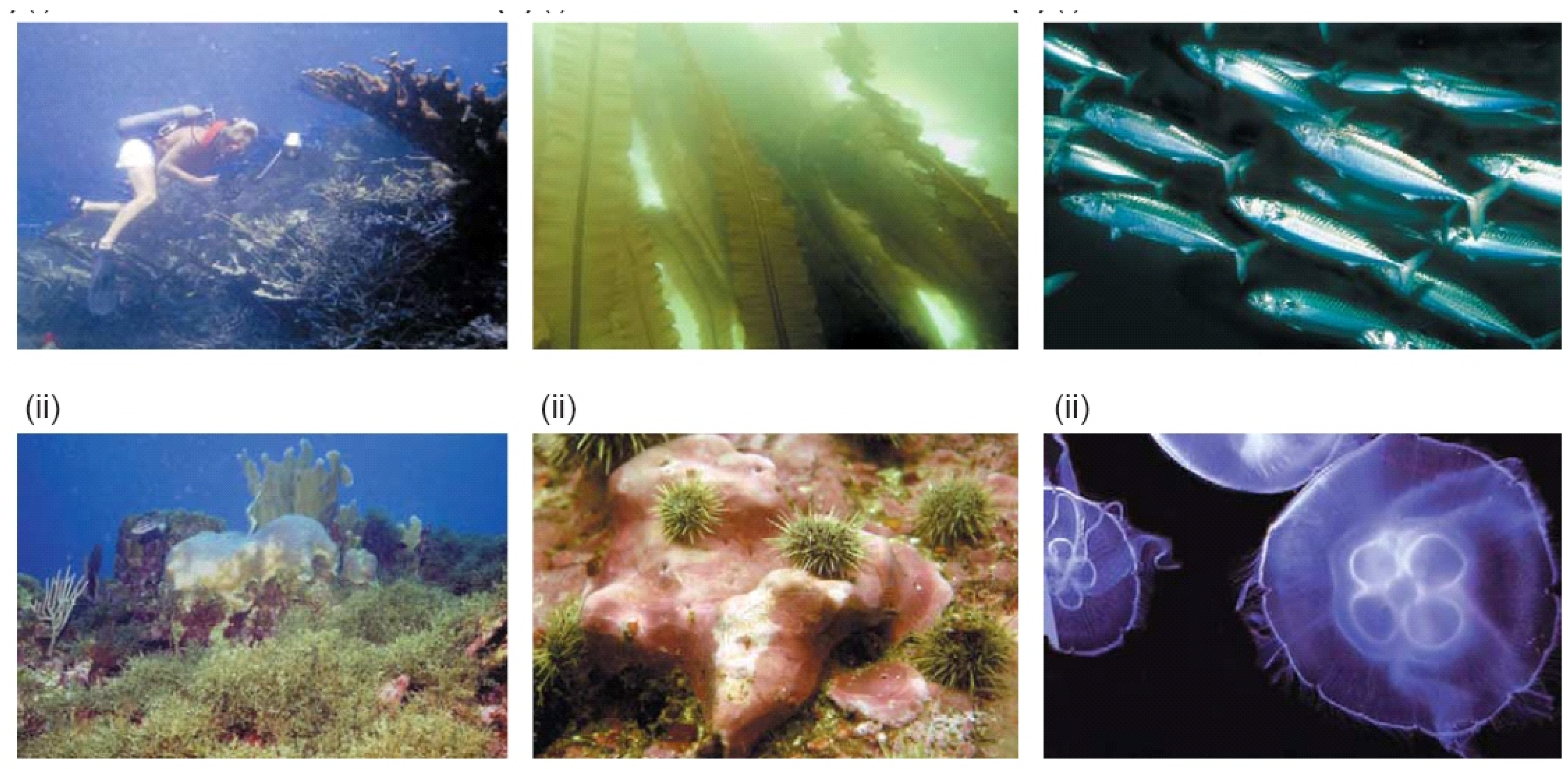
A conceptual model of how size-selective fishing and non-selective trawling modify the expected size spectrum of a community is proposed. Moreover, the constancy in the temporal pattern of size structure observed in already established fisheries, seems to suggest, from the point of view of size structure, stability of the community, but in an overexploited alternate regime. In order to implement a fisheries management strategy according to the balanced harvesting strategy recently proposed, it would be necessary to try to return the community / ecosystem to a not overexploited alternate regime in order to improve ecosystem services.



Schefer & Carpenter 2003

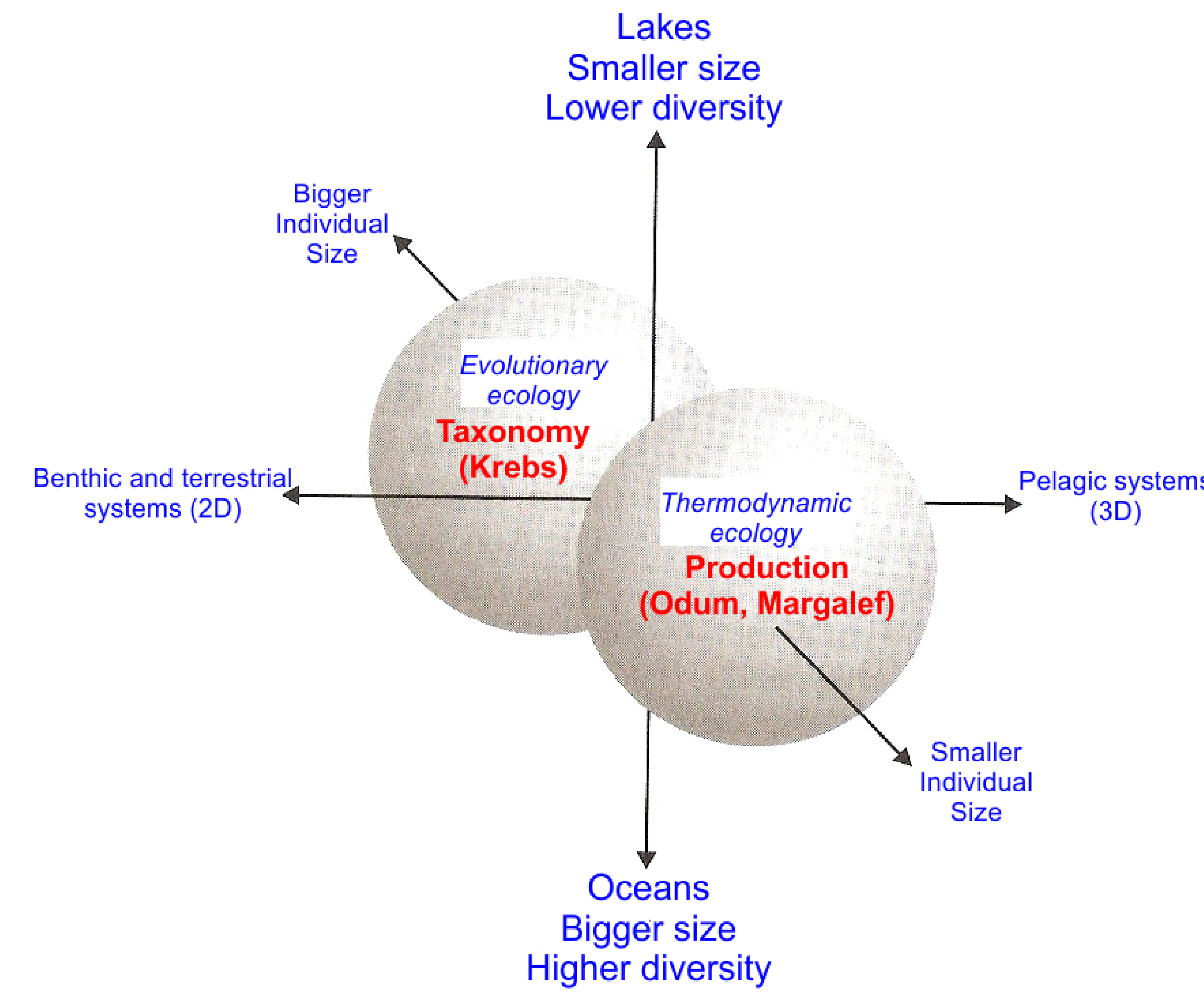
Before

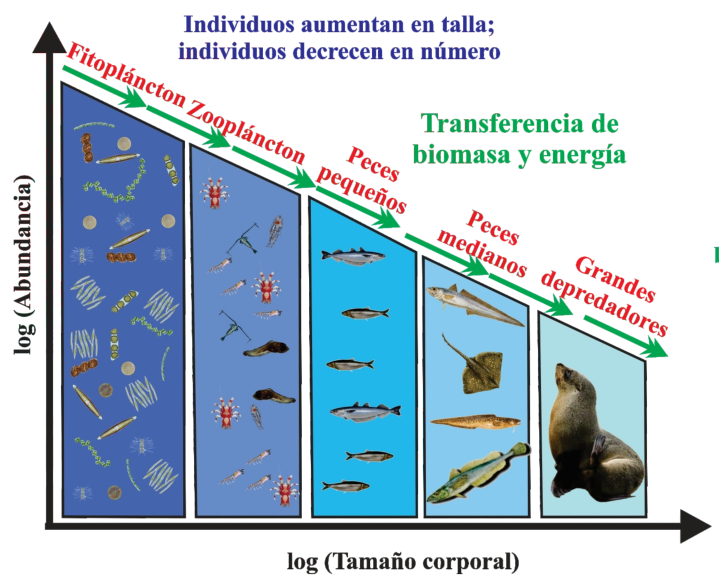
After

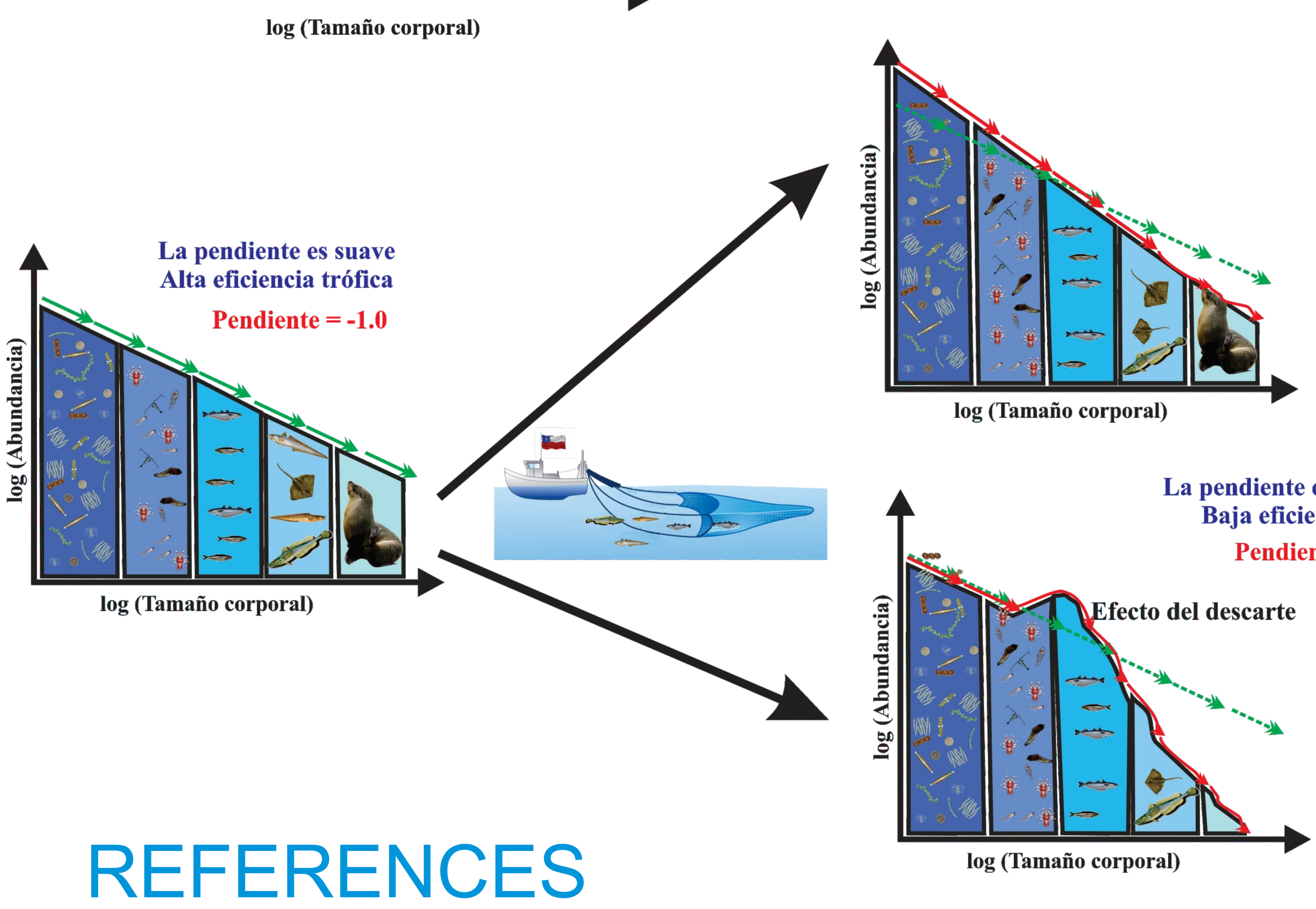


Hughes et al. 2005

There are no consensus regarding the definition of the stability of an ecosystem. For some authors the definition of resilience focuses on stability near a stable equilibrium state, where the rate and speed of return to the pre-existing conditions after a disturbance are used to measure the property (DeAngelis 1980). For others the definition emphasizes conditions far from any stable equilibrium point where instabilities can change the system to another basin of attraction which is controlled by a different set of variables and characterized by a different structure (Holling 1973). Lewontin (1969) raised the question whether it was possible the presence of more than one stable community in a given habitat, a situation he called "stable states", the intrinsic importance of this question is that the existence of these states would become unpredictable the ecosystems in the absence of historical information. Man is now able to modify the structure of marine ecosystems worldwide (Myers & Worm 2003), so the widespread existence of disturbances in marine ecosystems suggests that the concept might be better called attractors or alternate regimes rather than stable states (Scheffer & Carpenter 2003). In chronic human impacts (eg. Fishing) the return to the original state is impossible unless the impacts are reduced or eliminated altogether (Hughes et al., 2005). Moreover, some systems have changed to the point where it looks a recovery of the original species assembly is impossible (Scheffer et al. 2001). However, when we consider the allometric approach, we do not know whether there are these alternate stable states or regimes, (i.e, we do not know whether there are structures of different size depending on the environmental conditions or the impact of fishing).







Size spectrum research has shown that, in the absence of major disturbances, the size distribution of a community will present regularities and be relatively stable over time (eg. Sheldon et al., 1972). Several authors have proposed that fishing makes the slope of the Normalized Biomass Size Spectra (NBSS) steeper (i.e. more negative), because it selectively removes larger individuals and reduces survival (eg. Gislason and Rice, 1998), assuming that the linearity of the NBSS is not lost (Gómez-Canchong et al., 2011). However, ecosystems which are far from steady state can display nonlinear NBSS (Quiñones, 1994), and high levels of fishing may cause the size distribution of the biota to be drastically modified (Jennings & Kaiser, 1998). Based on a review of empirical information and simulations of a bio-energetic model, we suggested that fishing effects may be better captured by the curvature of the size spectrum than by its slope (Gómez-Canchong et al. 2013). Consequently, it is important to explore the use of non-linear size spectra (e.g. Pareto distribution) as a tool for analyzing community dynamics in heavily fished ecosystems. Our results also support the idea that species composition and size structure may respond differently to environmental disturbances (Gómez-Canchong et al. 2011). Several examples are found in the literature in which – unlike ours – species composition remains almost unaltered despite changes in the size structure. For instance, a negative temperature anomaly clearly affected the size distribution of zooplanktonic biomass in the central gyre of the North Pacific Ocean in the summer of 1969 (Rodriguez & Mullin, 1986b), nevertheless, the taxonomic approach did not show any effect of this temperature anomaly on the species composition of the macrozooplanktonic community (Rodriguez & Mullin, 1986b). A conceptual model of how size-selective fishing and non-selective trawling modify the expected size spectrum of a community is proposed (Gómez-Canchong et al., 2011). Moreover, the constancy in the temporal pattern of size structure observed in already established fisheries, seems to suggest, from the point of view of size structure, stability of the community, but in an overexploited alternate regime. In order to implement a fisheries management strategy according to the balanced harvesting strategy recently proposed (García et al. 2012), it would be necessary to try to return the community / ecosystem to a not overexploited alternate regime in order to improve ecosystem services.

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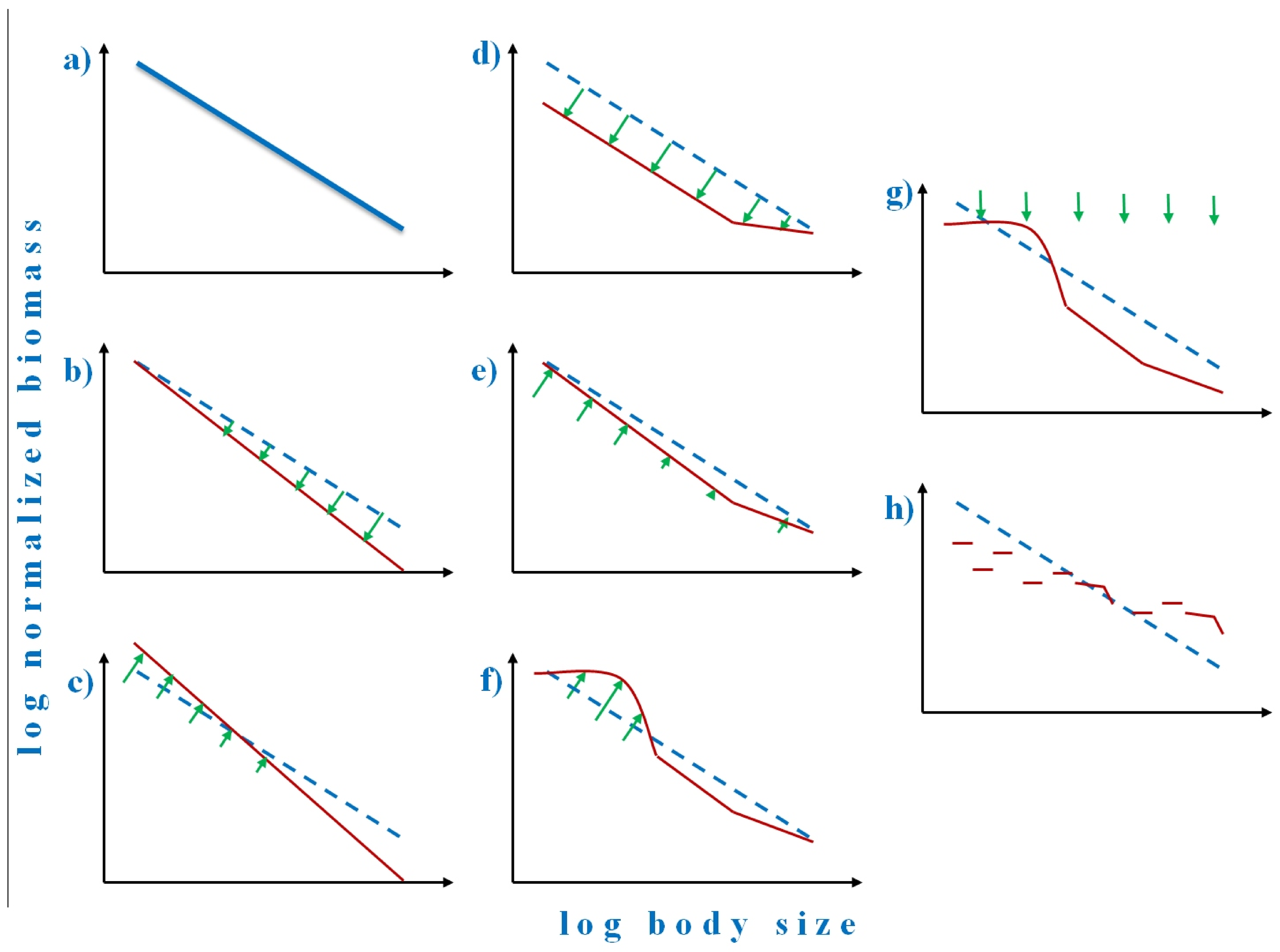

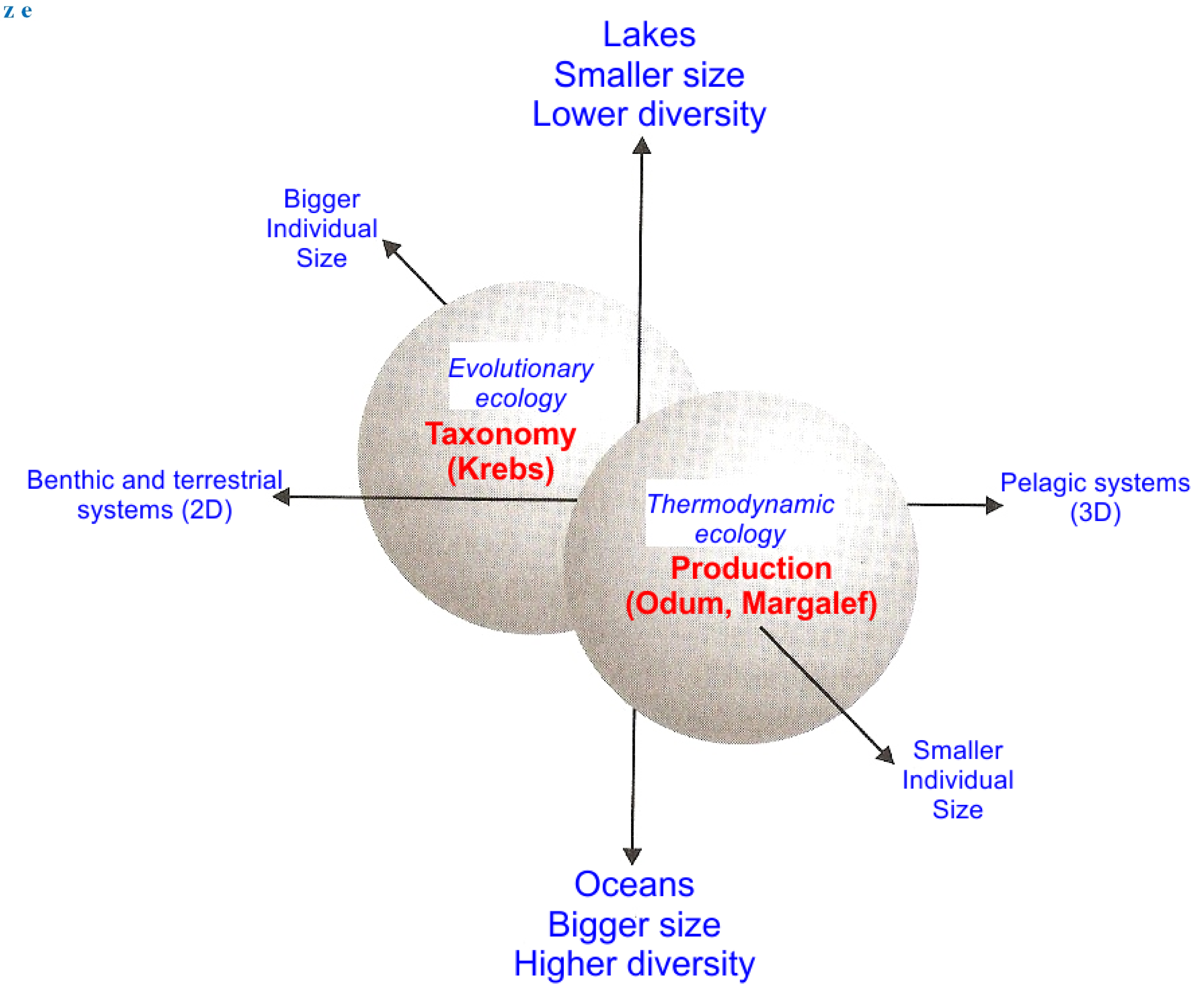

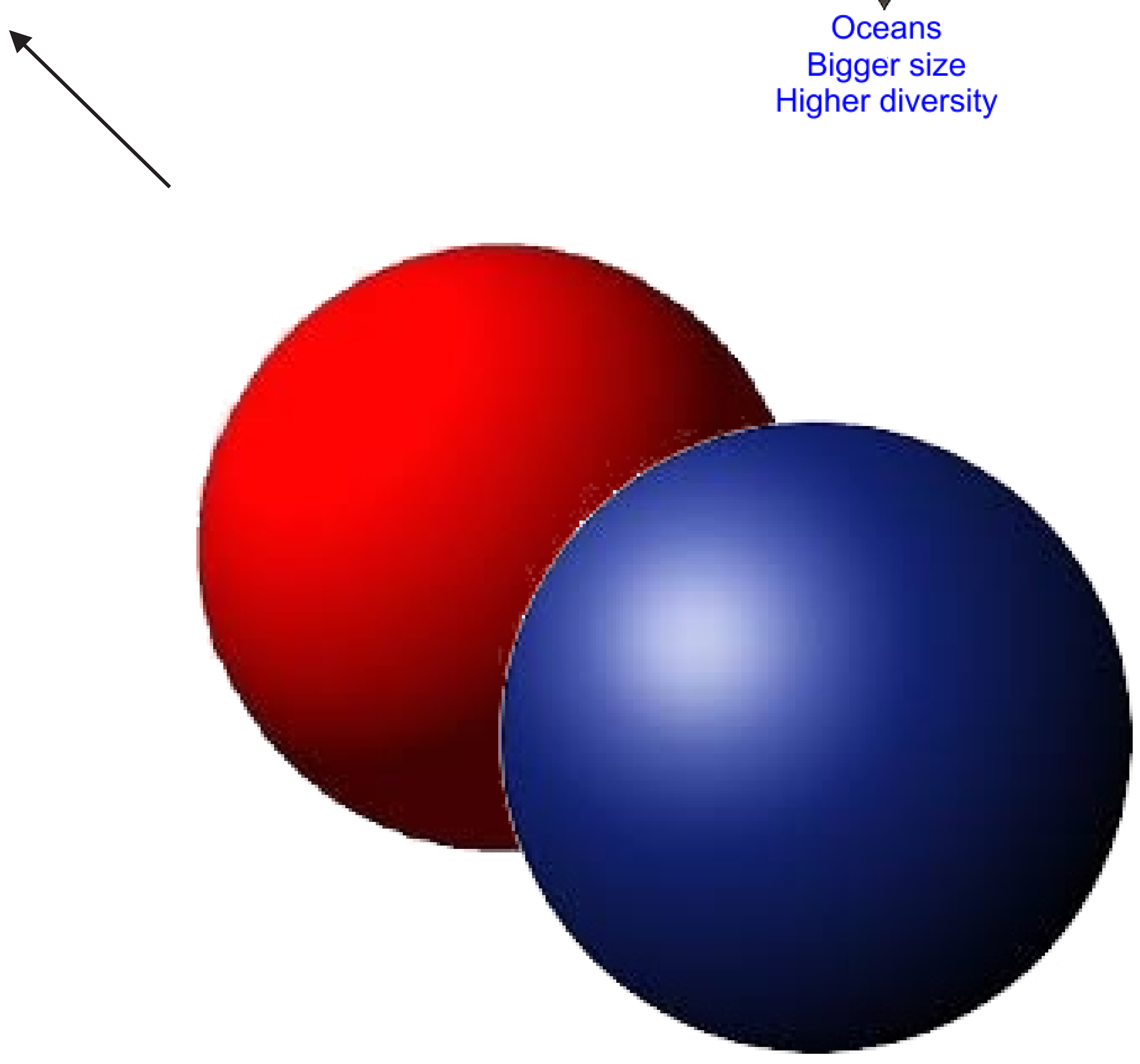

Lehman (1986); Rodríguez (1994, 2010)