On the rarity of tipping points and safe operating spaces in natural systems: implications for policy and management

IAN DONOHUE[1], HELMUT HILLEBRAND[2,3,4], W. STANLEY HARPOLE[5,6,7], DOROTHEE HODAPP[2,3], MICHAL KUCERA[8] , ALEKSANDRA M. LEWANDOWSKA[9], JULIAN MERDER[10], JOSÉ M. MONTOYA[11], JAN A. FREUND[10]

[1]School of Natural Sciences, Department of Zoology, Trinity College Dublin, Dublin 2, Ireland.
[2]Plankton Ecology Lab, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, Schleusenstrasse 1, 26382 Wilhelmshaven, Germany.
[3]Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg [HIFMB], Ammerländer Heerstrasse 231, 26129 Oldenburg.
[4]Alfred-Wegener-Institute, Helmholtz-Centre for Polar and Marine Research, Bremerhaven, Germany.
[5]Helmholtz Center for Environmental Research – UFZ, Department of Physiological Diversity, Permoserstrasse 15, 04318 Leipzig, Germany.
[6]German Centre for Integrative Biodiversity Research (iDiv), Deutscher Platz 5e, 04103 Leipzig, Germany.
[7]Martin Luther University Halle-Wittenberg, Am Kirchtor 1, 06108 Halle (Saale), Germany.
[8]MARUM – Center for Marine Environmental Sciences, University of Bremen, Leobener Strasse 8, 28359 Bremen, Germany.
[9]Tvärminne Zoological Station, University of Helsinki, J.A. Palménin tie 260, 10900 Hanko, Finland.
[10]Theoretical Physics / Complex Systems, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, Carl von Ossietzky Straße 9-11, D-26129 Oldenburg, Germany.
[11]Centre for Biodiversity Theory and Modelling, Theoretical and Empirical Ecology Station, CNRS and Paul Sabatier University, Moulis, France.

Concepts of thresholds, tipping points and regime shifts dominate current frameworks aiming to understand ecosystem responses to anthropogenic global change. A prevailing framework is the definition of threshold levels of pressure above which response magnitudes and their variances increase disproportionally. Based on 36 meta-analyses measuring more than 4600 global change impacts on natural communities, we find that threshold transgressions were rarely observed either within or across meta-analyses. Instead, ecological responses were characterized mostly by progressively increasing magnitude and variance when pressure increased. Sensitivity analyses with simulated data reinforce the contention that global change biology needs to abandon the general expectation that system properties allow definition of thresholds that separate minor from major ecosystem responses. Rather highly variable responses, even under weak pressures, suggest that 'safe-operating spaces' are unlikely to exist. I will discuss the profound implications of this finding for how we manage nature under global change.