Evidence for and against the existence of alternate attractors on coral reefs

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Testing for the existence of alternate attractors in ecosystems that possess slow dynamics and frequent pulse perturbation is exceptionally challenging. Coral reefs typify such conditions and the existence of alternate attractors is controversial. We analyse different forms of evidence and assess whether they support or challenge the existence of multiple attractors on Caribbean reefs, many of which have shown profound phase shifts in community structure from coral to algal dominance. Field studies alone provide no insight into multiple attractors because the non-equilibrial nature of reef dynamics prevents equilibria from being observed. Statistical models risk failing to sample the parameter space in which multiple attractors occur, and have failed to account for the confounding effects of heterogeneous environments, anthropogenic drivers (e.g. fishing), and major disturbances (e.g. hurricanes). Simple and complex models all find multiple attractors over some – though not all – regions of a system driver (fishing). Tests of model predictions with field data closely match theory of alternate attractors but a forward-leaning monotonic curve with only a single attractor can also be fitted to these data. Deeper consideration of the assumptions of this monotonic relationship reveal significant ecological problems which disappear under a model of multiple attractors. To date, there is no evidence against the existence of multiple attractors on Caribbean reefs and while there remains no definitive proof, the balance of evidence and ecological reasoning favours their existence. Theory predicts that Caribbean reefs do not exhibit alternate attractors in their natural state but that disease-induced loss of two key functional groups has generated bistability. Whether alternate attractors becomes a persistent element of reef dynamics or a brief moment in their geological history will depend, in part, on the ability of a persistent element of reef dynamics or a brief moment in their geological history will depend, in part, on the ability of functional groups to recover and the impacts of climate change and ocean acidification on coral growth and mortality.

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