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TITLE: Principles for managing marine ecosystems prone to tipping points

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ABSTRACT:

Abstract As climatic changes and human uses intensify, resource managers and other decision makers are taking actions to either avoid or respond to ecosystem tipping points, or dramatic shifts in structure and function that are often costly and hard to reverse. Evidence indicates that explicitly addressing tipping points leads to improved management outcomes. Drawing on theory and examples from marine systems, we distill a set of seven principles to guide effective management in ecosystems with tipping points, derived from the best available science. These principles are based on observations that tipping points (1) are possible everywhere, (2) are associated with intense and/or multifaceted human use, (3) may be preceded by changes in early warning indicators, (4) may redistribute benefits among stakeholders, (5) affect the relative costs of action and inaction, (6) suggest biologically informed management targets, and (7) often require an adaptive response to monitoring. We suggest that early action to preserve system resilience is likely more practical, affordable, and effective than late action to halt or reverse a tipping point. We articulate a conceptual approach to management focused on linking management targets to thresholds, tracking early warning signals of ecosystem instability, and stepping up investment in monitoring and mitigation as the likelihood of dramatic ecosystem change increases. This approach can simplify and economize management by allowing decision makers to capitalize on the increasing value of precise information about threshold relationships when a system is closer to tipping or by ensuring that restoration effort is sufficient to tip a system into the desired regime.

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