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Ecosystem-based management in a complex and interconnected world

Ecosystem-based management has emerged as an important holistic approach for promoting the health, functioning, and resilience of exploited marine ecosystems. However, its application is fraught with difficulties due to the complex and interconnected nature of real systems. Here, I use a spatially-explicit predator-prey model to show that ecosystem-based management via reserve networks can achieve optimal results for trophically-coupled species when they undergo unpredictable dynamics but not when they reach a stable equilibrium. This "paradox of predictability" suggests that ecosystem-based management may be more broadly applicable in nature than previously thought.

To determine whether these results hold for more complex ecosystems that are coupled by both organisms and material, I develop a spatially-explicit meta-ecosystem model to understand how reciprocal feedbacks between local ecosystems affect the optimal allocation of reserves to manage an herbivorous fish-macroalgae-coral community. I show that there is a trade-off between local and regional conservation objectives when designing reserve networks: Small and aggregated reserves based on the extent of dispersal maximize the abundance of corals and herbivores regionally, whereas large and isolated reserves always maximize the abundance of corals within reserves, regardless of the extent of dispersal. The existence of such "conservation traps", which arise from the fulfillment of population-level objectives within local reserves at the cost of community-level objectives at regional scales, suggests the importance of adopting a more holistic strategy to manage complex and interconnected ecosystems.