Ocean currents and herbivory drive macroalgae-to-coral community shift under climate warming

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Range shifts in foundation species induced by global warming are likely to have ecosystem-wide implications for biodiversity, ecological functioning, biogeochemical cycling and resources used by humans. Corals and macroalgae are habitat-forming species in coastal ecosystems that co-occur and compete for space, and thus global degradation of coral reefs and macroalgal beds can have ecosystem-wide implications. However, recent studies in warm temperate zones have documented community shifts from macroalgae to corals, signaling a potential mechanism for coral conservation under climate warming at the expense of macroalgae under climate warming. Although such community shifts are expanding geographically, our understanding of the driving processes is still limited. Here, we reconstruct long-term climate-driven range shifts in 30 species of macroalgae (8 kelp and 22 fucoid species), 12 species of corals and three species of herbivorous fishes (records of overgrazing) from over 60 years records (mainly 1950–2015) stretching across 3,000 km of the Japanese archipelago from tropical to subarctic zones.

The direction and rate of the observed range shifts calculated for each species and coast during the study period showed considerable variation in both distribution centroids and range edges. Expansions were scarcer than contractions in macroalgae, whereas fishes and corals experienced expansions much more frequently than contractions. Expansions were fastest in fishes, followed by corals, fucoids and kelps, whereas macroalgae contracted their range faster than corals and fishes. Based on a revised coastal version of climate velocity trajectories and a Bayesian inference, we found that prediction models combining the effects of climate and ocean currents consistently explained observed community shifts significantly better than those relying on climate alone. Corals and herbivorous fishes performed better at exploiting opportunities offered by this interaction.

The contrasting range dynamics for these taxa suggest that ocean warming is promoting macroalgal-to-coral shifts both directly by increased competition from the expansion of tropical corals into the contracting temperate macroalgae, and indirectly via deforestation by the expansion of tropical herbivorous fish. Beyond individual species' effects, our results provide novel evidence on the important role that the interaction between climate warming and external forces conditioning the dispersal of organisms, such as ocean currents, can have in shaping community-level responses, with concomitant changes to ecosystem structure and functioning. Further, we found that community shifts from macroalgae to corals might accelerate with future climate warming, highlighting the complexity of managing these evolving communities under future climate change. Nevertheless, and although expansion rates are faster than contraction rates overall, we found that not only macroalgae but even corals might be unable to keep pace with climate change. This may suggest that the apparent expansion in overall range might be a transient effect potentially masking risk of metapopulation collapse with decreasing connectivity among local populations and future range collapses. Thus, future conservation of these communities might require of a more proactive management towards climate adaptation including abundance control of herbivorous fishes, artificial assistance for thermal adaptation through selection of thermal-tolerant lineages, or relocation and translocation into cooler areas.

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