

Foundations of kelp forest restoration PART 1: resilience, environment-engineer feedbacks and habitat mosaics

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The kelp *Ecklonia radiata* is the most widespread habitat-forming macroalgae in temperate Australasia. The underwater forests created by this species provide structurally complex habitats that support extremely productive food webs and high levels of biodiversity and endemism. Unfortunately, in Australia (and elsewhere) kelp forests are declining, with habitat degradation manifesting as increased patchiness and a reduced density of adult kelp. Restoring degraded kelp habitats can assist in the conservation of these critical ecosystems, however the success of restoration efforts requires a thorough understanding of the demographic processes of kelp and their effects on kelp forest resilience. We created a reef complex – consisting of 28 experimental reefs covering over 1.5 ha – onto which over 500 adult kelp were transplanted. Using this unique environment, we examined (i) how the physical environment within kelp canopies changes with variations in patch size and kelp density and (ii) how these changes feedback to affect the demography and resilience of kelp habitats. Reductions in patch size and kelp density has marked effects on the physical environment beneath the kelp canopy, particularly light levels and sedimentation. These changes subsequently have a strong impact on the health of juvenile kelps and importantly, play a significant role in the ability of transplanted kelp reefs to be self-sustaining. Different densities of adult kelp also appear to positively affect separate demographic processes such as recruitment and growth. Healthy kelp forests appear to facilitate their stability and resilience through environmental modifications that benefit their future generations. Consequently, the creation and maintenance of this positive-feedback, along with the provision of a mosaic of kelp densities, appears critical to the success of future kelp forest restoration efforts.