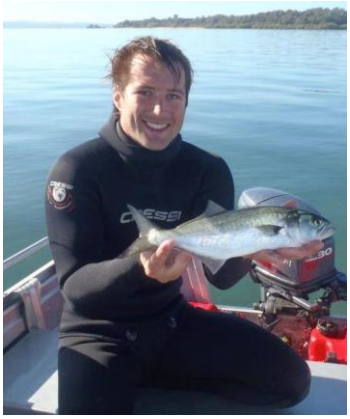
Promoting resilience of marine ecosystems through connectivity



Project team

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Timeframe

Ongoing

Project description

Ecosystems offer many services that humans depend on, but unfortunately these same ecosystems are damaged by some of our own actions. We asked the question: what we can do to build the resilience of ecosystems?

First we needed to understand what confers resilience on ecosystems. We were specifically interested in how connectivity among different components of ecosystems influences resilience. We used a series of projects from innovative, small-scale lab experiments to field tests of resilience of seagrass meadows and coral reefs using genetics, underwater survey techniques and mathematical network analysis.

Outcomes

Although connectivity is highly regarded as important for ecosystem resilience, we actually have little idea how to manage connectivity in the sea. We have used field and lab-based experiments, followed by mathematical modeling, to identify practical solutions for enhancing resilience by improving our understanding of the effect of connectivity.

Connectivity structures populations, communities and ecosystems in the sea. The extent of connectivity is, therefore, predicted to also influence the outcomes of conservation initiatives, such as marine reserves. We analysed the global literature on the effects of seascape connectivity on reserve performance and found that in the majority of cases, greater seascape connectivity inside reserves translates into better conservation outcomes. However we also found that remarkably few studies explicitly studied connectivity, whereas in terrestrial ecology this has been very well studied. So there's a real need for marine scientists to integrate the knowledge from forest ecology into marine conservation.

In Moreton Bay in Queensland, Australia, we used a mathematical model (called network analysis) of seascape connectivity for coral reef-associated fish. We checked how well the existing marine reserve network protects the key reefs and the critical connections between reefs. From a connectivity perspective, nearly all of the important components of the reef ecosystem were in fact not protected at all!

We now know we can do way better than that. When the Moreton Bay Marine Park was designed and planned this type of connectivity information was not available. But now that we have it, the guiding principle of protecting connections among habitats can be achieved more effectively in future, by formally incorporating our findings into the decision framework.

The removal of algae by herbivorous fish is a key ecological function on coral reefs that promotes coral growth and recruitment and thus is linked to resilient ecosystems. In the field, we used a coral reef seascape in eastern Australia to test whether seascape connectivity and reserves influence herbivory. We found that connectivity and reserve status jointly affect the functioning of ecosystems. You need both together to get maximum benefit of marine reserves. The effectiveness of conservation initiatives clearly depends on our ability to understand and predict how these multiple interactive effects structure ecological functions. These findings have wider implications for the spatial conservation of complex marine environments and strengthen the case that the impact of conservation on ecosystem functioning is contingent on how reserves are positioned in seascapes.

Connectivity can influence resilience at different spatial scales. Ecosystems are made up of multiple distinct patches, linked in a variety of ways. The number of links that exist and how they are arranged spatially determines the connectivity of an ecosystem. Using small-scale lab experiments we demonstrated empirically that to promote the resilience of ecosystems we need to pay attention to how individual patches within the systems are connected. It is all very well to consider the ecosystem as a whole (e.g. the Great Barrier Reef), where overall high connectivity may be present and maintain overall resilience. But for individual patches within that ecosystem (for e.g. a single coral reef, which might be particularly important for a tourist operation or turtle breeding area), we cannot overlook the local-scale connectivity, which will be just as important in determining how resilient the place is to major impacts.

Working towards a resilient future for our ecosystems requires a thorough understanding of what enhances resilience. Connectivity is a key aspect linked to ecosystem resilience and, using a variety of methods, our research has improved the knowledge and understanding of the connectivity-resilience relationship. We have come a long way. And are continuing our quest to provide better information for coastal decision makers to sustain our ecosystems and the services we rely on.

Funding

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Publications

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