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# Adaptive Management of Temperate Reefs for Climate Change: new approaches for ecological monitoring and predictive modelling



## Climate change necessitates adaptive management of Australia's temperate reefs

Australia's southeast marine waters, alongshore of Australia's most densely populated coastline, are warming at 3-4 times the global average rate – the most rapid change in the Southern Hemisphere[1]. Ecosystems in this region are severely threatened and significant biodiversity changes are anticipated[1], including loss of diversity[2]. Ecosystem changes associated with climate change will require wise decisions about where, how, and when to apply particular adaptive management interventions[3].

Theoretical frameworks and model experiments dominate climate change science. However, complex social and ecological processes which should accurately inform potential adaptive management strategies still lack a scientific foundation underpinned by in situ measurements[3]. This project combines long-term and spatial ecological datasets from temperate reefs, with remotely sensed environmental characteristics, to determine climate-forced signals in ecological responses. This critical data synthesis, analysis and predictive modelling will better inform likely future species changes and practical adaptive management responses to help build resilience. Unless protocols for tracking and predicting ecological changes are well informed, the remote nature of marine habitats, with associated difficulties and expense when mapping biodiversity assets, will inevitably translate to poorly-conditioned management responses.

## 20-year quantitative reef surveys and environmental data explain past changes

Central to this project is the spatial and temporal analysis of a unique dataset compiled by the Institute for Marine

## Objectives of the Project

| GOAL | | BENEFIT |
|---|---|---|
| 1. To build a database of remotely-sensed and other physical environmental data that corresponds to locations included in long-term Marine Protected Area and Reef Life Survey monitoring programs. | → | enable easy access to ecological and environmental databases for temperate reefs. |
| 2. To identify climate change impacts on inshore communities and also environmental predictors of those impacts that are relevant to managers. | → | benchmark changes to the environment, and to enable an assessment of possible adaptive responses. |
| 3. To identify indicator species/ groups for monitoring that respond measurably to the climate. | → | Identify triggers to inform the need to adapt management. |
| 4. To engage with stakeholders to develop adaptive management of temperate reefs to manage climate change impacts, and assess the monitoring requirements necessary to inform this process. | → | develop practical frameworks for managers that integrates scientific information and managerial constraints. |

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and Antarctic Studies (IMAS) dating back to 1992, involving quantitative surveys of reef fishes, macro-algae, coral, urchins, abalone, rock lobster and other macro-invertebrates at >600 sites off southeast Australia[4]. Data include long-term series at Marine Protected Area (MPA) locations along the latitudinal gradient from NSW to southern Tasmania. This represents one of the longest ecological monitoring records worldwide for contrasting ecological changes within a regional MPA network with controls at fished locations in a region subject to prolonged warming over the past 60 years. Thus, when coupled with environmental data, the ecological datasets will enable the unprecedented analysis of marine species' distributional change over the past two decades. Broad-scale environmental data (ocean temperature, salinity, chlorophyll) will be related to the marine ecological record across all sites to identify ecological changes associated with:

(i) the marine physical condition during years of significant climatic anomalies (e.g., El Niño and La Niña);

(ii) stresses from fishing; and

(iii) interactions between these two factors.

The latter will be particularly important in identifying how fishing and climate changes interact.

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## Modelling sensitive species and robust locations to inform monitoring for climate change

Species distribution models serve to statistically estimate relationships between species abundance records and environmental predictors. The usual assumptions that ecological interactions between species can be ignored in models, and that distributional responses to climatic shifts are rapid, will be tested by cross-validating climatic envelope models developed on the basis of latitudinal distributional patterns with measurements of temporal ecological change at sites surveyed in anomalously hot and cold years. The project's findings aim to inform monitoring, underpinning the need to continually observe temperate reefs in our region to provide the necessary feedback for management agencies to both detect and understand the nature and magnitude of changes occurring[1]. Given that such monitoring programs are expensive, and often have specific objectives (such as MPA management), they need to be refined with respect to providing cost-effective yet robust detection of biotic responses to climate change[3]. This project will identify the locations, species subsets, monitoring frequency and replication that have provided the strongest signal so far, and be used to make recommendations about future observing protocols to guide funding bodies and management agencies.

## Alternative management recommendations

Where increased protection from fishing is shown to increase/decrease resilience or resistance to climate change, the ecological benefits of various adaptive management strategies will be assessed. In all determinations of potential future adaptive management arrangements, possible options will be scoped with state management agencies, to ensure options are realistic and feasible.

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## About the Marine Adaptation Network

The Adaptation Research Network for Marine Biodiversity and Resources (a.k.a. the Marine Adaptation Network) is hosted by the University of Tasmania and convened by Assoc Prof Neil Holbrook. The Network is supported by 14 partner institutions nation-wide. It comprises a holistic framework of interconnecting marine themes that cross-cuts climate change risk, marine biodiversity and resources, socio-economics and policy. This interdisciplinary network aims to build adaptive capacity and adaptive response strategies for the effective management of marine biodiversity and living marine resources under climate change. For more information on the Marine Adaptation Network, or to subscribe to become a member of the Network, please visit <www.nccarf.edu.au/marine/>.

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