Climate Change Adaptation Research Grants Program
- Marine Biodiversity and Resources Projects

Project title:
Adapting to the effects of climate change on Australia's deep marine reserves

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Lead organisation: CSIRO Climate Adaptation Flagship

Objectives:
1. To develop practical options for DEWHA to manage the impacts of climate change on the South-east Commonwealth Marine Reserve
2. To develop a generic model that can be applied to forecasting the impacts of climate change on other deep sea biota

Methods:
The project's objectives will be achieved by (1) developing and validating a biologically realistic model of the distribution of Australia's principal reef-forming deep-sea coral, *Solenosmilia variabilis*, that includes information on its sensitivity to environmental factors such as temperature, salinity and carbonate saturation state, (2) using this model to forecast the coral's potential distribution under different climate change scenarios, (3) identifying possible refugia for the community, which could be considered for management protection, if needed, and (4) liaising closely with DEWHA regarding management implications and strategies.

1. Model development and validation: The forecast model will be developed in collaboration with the Marine Conservation Biology Institute (Seattle, USA), NIWA (NZ) and the CERF Marine Biodiversity Hub. MCBI has in hand a presence-only model (MaxEnt) that it is using to predict the distribution of modern deep-sea reef-forming corals (Guinotte, et al., Pew Charitable Trusts, Final Report, 2009). This model is immediately available to the project, but is generic, and needs to be customized to S. variabilis in the SW Pacific region. NIWA has been analyzing and attempting to predict the distribution of corals on NZ seamounts using Boosted Regression Tree Analysis (A. Rowden, pers. comm.) and to relate those distributions to the outputs of global maps of carbonate saturation horizons, roughly downscaled to New Zealand waters (Bostock, et al., Abstract, 4th Internat. Deepsea Coral Symp., 2008). Their model structures are at an early stage of development, and have been discussed with MCBI in the context of a regional comparison of models and integration of results. We will participate in that integration, to develop and validate and optimal forecast model structure. This assessment will be informed by the work of the CERF Marine Biodiversity Hub, which has assessed the accuracy and systematic error of different model classes when used to predict the modern distributions of marine benthos from patchy field data (N. Bax, pers. comm.). The CERF background work will inform the choice of models used in this project, against the background of the amount and reliability of information available of the target species' environmental tolerances (see below) and environmental maps of the region. At the moment, the default model we will use is the MCBI model, which is in hand, but we will hold a small workshop in Hobart early in the project (March-April, 2011) to discuss other possible models, the data requirements for each, and their suitability for use in the present project.

All models will be informed by CSIRO's integrated oceanographic data sets (in particular, the CSIRO Atlas of Regional Seas [CARS], which is being up-graded to include nutrient data), sea bottom topography and substratum maps (accessed via the CERF Marine Biodiversity Hub and GA), and CSIRO's regionally downscaled state-of-the-art ocean carbonate models. The last will be tested and refined against historical measurements made locally (CARINA Group. U.S. Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/otg.CARINA.SO.V1.1, 2010) and against near-bottom and water-column measurements made on and around the Southern Hills seamounts in January 2009

(Thresher, et al.,, ms.). Additional carbonate profiles to ground-truth and tune the carbonate model will be obtained near S. variabilis reefs off NE Tasmania in November 2010 (ship-time already allocated).

The environmental tolerances of S. variabilis are central to developing an accurate predictive model for the species. These tolerances will be determined three ways, as no single assay is likely to be definitive. In aggregate they should provide a good measure of the temperature, salinity, oxygen and carbonate requirements of the species.

2. The completed model will be driven in forecast mode using a three-dimensional model for ocean carbonate saturation state, that we have in hand, down-scaled to the reef area. The downscaling and ocean forecasting will be done by R. Matear (CSIRO), a world authority on ocean carbonate modeling, at no cost to this project. Projected regional changes in other factors, such as regional productivity, surface and sub-surface temperatures and salinity, will be input as spatially explicit data from other climate forecasts models that have been developed by CSIRO MAR. During the deployment of the predictive model, information will be shared (in a two way process) with the Atlantis modelling group so that consistent environmental properties and impact assessments are used in the two cases.

3. Project output will be a series of maps showing probability distributions of habitat suitable for deep-sea coral reefs in the Australian region, under a range of different climate change scenarios. The use of these maps to guide management decisions has already been discussed with DEWHA, and further discussions will be held as the project progresses. Currently, the fate of the reef assumes it has limited options to move into shallower regions, due to the minimum depths of its known seamount habitats. This prediction may be wrong. Swath maps of the SW corner of Tasmania, for example, indicate hard ground in the depth range of 200-1500 m, less than 100 km away from the reefs in the Commonwealth Reserves. This area is unexplored biologically, but could provide a pathway for the community to move into shallow areas if forced to by climate change. We also know that reef communities similar to those in the Commonwealth Reserves exist outside of the reserves, such as off NE Tasmania and in the Great Australian Bight. The forecast model will be used to determine if areas where the coral is now found will remain suitable for its continued presence and, if not, where, if anywhere regionally, refugia will exist. If so, it will provide managers options of extending protection to them, if needed, to ensure their utility as refugia.

Even if refugia for the S. variabilis reef develop locally and can be protected, the long life span of the coral, its likely limited ability to disperse, and the rapid rate of climate change may make it difficult for it to naturally colonize new areas in time to survive. Human-assisted translocation may be required, as has been suggested for some threatened terrestrial communities. We will undertake a desk-top evaluation of this option and formulate a research plan to test its potential, as a possible follow-on project.