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

Project title:
Management implications of climate change impacts on fisheries resources of northern Australia

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Objectives:
1. Describe the projected climate-driven changes that are relevant to northern Australian marine fisheries.
2. Assess the potential impacts of climate change on key fisheries and species in northern Australia.
3. Assess current management to identify approaches that are adaptive to potential climate change scenarios

Methods:
Objective 1: Describe the projected climate-driven changes that are relevant to northern Australian marine fisheries.
Using outputs from existing global climate model ensembles (GCM's; eg. CSIRO Mk3.5) and oceanographic models (Bluelink) the key environmental variables predicted to change in northern Australia due to climate change will be determined as will the nature and extent of these changes. Typically GCMs provide temporal scale predictions of decades, and spatial scales in the order of 200-250 mile grids. However, in Queensland at least there are regional scale projections available to spatial scales of 10-25 km. Regional projections in Queensland are available for variables such as atmospheric temperature, which has been demonstrated to be a suitable proxy for estuarine water temperature (Robins, personal communication), and for rainfall patterns, which can also be used as an indicator of river flows (EPA 2008). Regional projections of climate change in Queensland have also been produced by the Queensland Climate Change Centre of Excellence in 2009, in association with CSIRO and the Bureau of Meteorology, and will also be useful in providing regional scale projections of climate events such as rainfall, river flows and cyclones, as well as atmospheric temperature. There are also climate projections specific to the Great Barrier Reef developed by AIMS in collaboration with NOAA using GCMs for air and sea temperature, sea level rise, ENSO, rainfall, tropical cyclones and ocean chemistry that can be used where other data is not available or cannot be downscaled (Lough 2007).

The oceanographic model 'BLUElink' has been developed by CSIRO, the Australian Bureau of Meteorology and the Royal Australian Navy to provide ocean forecasts for the Australian region on variations in ocean currents, ocean eddies and water temperatures. Recent substantial research efforts in regions such as SW Australia have produced downscaled projections of key oceanographic processes using the BLUElink model, however for northern Australia similar downscaling capabilities have not been developed and is beyond the scope and capacity of this proposed project. Current work by the Australian Institute of Marine Science and CSIRO is developing a 3-dimensional hydrodynamic model for the Great Barrier Reef that has the ability to hindcast and ultimately predict the effects of riverine inputs onto the shelf area thus providing scenarios of sea temperature and salinity. These can be used to examine impacts on fisheries catch, catch-per-unit-effort and recruitment success from past high rainfall events, but also to predict likely future scenarios of these variables based on climate forecasts. Currently the model has a spatial resolution of 4 km and is being refined to provide a resolution of 1 km.
All up-to-date climate change projections for northern Australia will be collated and documented early in the project as part of Milestone #2. As more detailed projections at local spatial scales are developed during the life of the proposed project, these predicted changes will be updated towards the end of the project to ensure that the most up to date forecasts are used for determining likely

future impacts (Milestone #4). These will be extrapolated across the largest area of northern Australia feasible based on the regional scale approach in determining relationships between fisheries and environmental variables, to provide predictions of the potential impacts on fisheries across all regions of northern Australia.

Objective 2: Assess the potential impacts of climate change on key fisheries and species in northern Australia.

a) An initial project workshop will be convened (Milestone #1) involving key project members, including fisheries managers, industry representatives and representatives from the WA and SE fisheries climate change projects to discuss and plan the full project.

b) Literature review of tropical species sensitivity and adaptive capacity to environmental change (Milestone #2) to assess the sensitivity and capacity for key species to adapt to potential climate change impacts. This will be useful in providing a comprehensive information base to focus correlative analyses and to determine through inference the potential impacts on species where insufficient data is available and/or data analyses fail to detect correlations between fish populations and environmental change. Examples of the types of literature include experimental studies on responses to physical variables, known and inferred species tolerance ranges, habitat requirements, mobility, and population dynamics such as stock structure.

c) Examination of environmental data sets to provide an understanding of historical climate variability and the key environmental trends in the marine environment for northern Australia including i) ENSO events, ii) rainfall patterns, iii) river flows including nutrient and sediment loads, iv) air and sea temperature, salinity and pH, v) cyclone frequency and intensity, vi) sea level rise and vii) critical fish habitat status and trend. These data sets will be examined for seasonal and annual patterns (Milestone #3).

d) Determine the effects of environmental variables on fish stocks at spatial and temporal scales relevant to fisheries and depending on data resolution (Milestone #4).
Correlative analyses will be carried out using fisheries data sets and environmental data sets to determine the sensitivity of fished resources to biophysical variables in each of the key regions identified for fine-scale analyses. Key fish species will be used as case studies based on their fishery importance and availability of data. Preliminary correlative analyses of sub-sets of data for each species and available fisheries data will be carried out to determine the value in carrying out full analyses across the full extent of spatial and temporal scales possible, and for the various environmental variables being examined. All data will be screened and adapted if necessary to optimise their utility for analyses. The key population process to be examined will be recruitment indices and how this is impacted by fluctuations in environmental variables and in the timing of seasonal changes in the environment. Other population characteristics (eg. growth) will be considered where possible. Fisheries data sets used will be from fisheries-dependent sources such as commercial logbooks, observer data programs, voluntary logbooks and/or interviews (eg. CapReef), and from fisheries-independent data sources such as long-term monitoring and research programs. There is uncertainty in the level of data manipulation required for the various data sets (fisheries and environmental) and the time this requires. Therefore, we will adopt a prioritized approach whereby species to be analysed will be listed in order of decreasing priority (based on numerous factors, eg. value, catch level, stakeholder views) and analyses will be conducted on as many of the listed species as time and data will allow.

e) Identify potential impacts on fisheries based on climate and oceanographic model projections and the sensitivity of key species to changes in environmental variables (Milestone #4).
Using information above we will derive the nature and extent of sensitivity of key fishery species to climate change, and identify key environmental variables in order to identify the potential impacts climate change may have on fish species and their fisheries under the predicted scenarios. To do this we will be using the vulnerability assessment framework adopted by the IPCC (Schroter et al 2004) in identifying the likely impacts of climate change on fisheries resources of northern Australia. This

framework provides a structured approach in determining the potential impacts of climate change that also provides transparency to stakeholders. It combines the elements of EXPOSURE and SENSITIVITY in determining POTENTIAL IMPACTS and can be used for individual species or in a fisheries context and readily provides an index of climate change vulnerability for fisheries (eg. Johnson and Welch 2010). This approach was used in assessing the vulnerability of species groups and habitats of the Great Barrier Reef to climate change (Johnson and Marshall 2007), and is being used currently to assess the vulnerability of fisheries and aquaculture in the Pacific to climate change to identify adaptive management options that protect fish resources for subsistence and commercial fisheries (SPC 2009). The framework allows the key determinants of impacts to be readily identified and will enable targeted policy and adaptive management to effectively allocate resources to species and regions that have the greatest vulnerability to projected climate change.

Objective 3: Assess current management to identify approaches that are adaptive to potential climate change scenarios (Milestone #5).

A final workshop will be run at the end of the project with industry, managers and relevant stakeholders to discuss the results of the sensitivity analyses and discuss the predicted impacts on industry, plus to obtain feedback on industry knowledge and observations, providing an opportunity to integrate fisher knowledge with scientific knowledge. This workshop will involve an assessment of current policy that delivers management in northern Australian fisheries to determine its capacity to be effective under the future scenarios identified for fisheries. A major outcome from this workshop will be the identification of pragmatic and realistic policy adaptation options and opportunities for managers and the respective fishery sectors for fisheries in northern Australia.