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Climate change and Australian marine and freshwater environments, fishes and fisheries: introduction

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Introduction

There are worldwide concerns over the effects of climate change on both environments and human communities, with a need to better understand the range of existing and potential impacts. The Earth's climate has changed rapidly in the past few decades (Steffen 2009), largely caused by human activities (IPCC 2007). Climate change is a global problem that will require global solutions, and these will take time both to achieve and take effect. Until then, there is a need for prioritised management actions in the form of species- and/or site-specific adaptations to changed climatic conditions. Although there is a recognised need to use the best available science to support evidence-based policy and management (Ryder *et al*. 2010), there is typically a lack of uptake of science into conservation management (Koehn 2004), with the effective translation of scientific findings into policy and on-ground practice still limited, especially in freshwater science (Lake *et al*. 2010). The political debate that surrounds climate change can cloud scientific findings and there is a need for clear scientific messages to politicians, the public and resource managers on climate change (see Australian Academy of Science 2010) and its impacts (see papers in this Special Issue).

Climate change is already affecting many aspects of marine and freshwater ecosystems, their fishes and fisheries, and the human uses of them. This includes commercial and subsistence fisheries and the people who rely on them (Bell *et al*. 2009) as well as non-market benefits such as biodiversity and ecosystem services. These latter benefits are often neglected in economic evaluations. Importantly, these impacts will not only be for today but also into the future. Climate-change impacts are not the only stressors to aquatic ecosystems, and in many cases, will not be the primary threat to fish or fisheries. However, an understanding of how climate change might interact with these other stressors is crucial for management and protection of biodiversity and ecosystem goods and services. Papers in this Special Issue explore these complex inter-relationships for Australian marine, estuarine and freshwater systems.

Climate change, fish and fisheries in Australia

Australia is a large, generally dry continent that spans tropical to temperate zones. It has a long continuous coastline but few mountains, limiting opportunities for cool-climate freshwater species to move to higher altitudes to compensate for increasing temperatures (Koehn *et al*. 2011). Australia has a valuable marine fisheries zone, high levels of tourism in coastal areas (Koehn *et al*. 2011) and angling is a popular recreational pastime, particularly in freshwater, estuarine and inshore marine environments (Henry and Lyle 2003). Whereas some attention has been paid to the impacts of climate change on marine areas (Poloczanska *et al*. 2007), particularly those with high profiles such as corals and the Great Barrier Reef (see Munday *et al*. 2008; Pratchett *et al*. 2011), freshwater ecosystems may be more vulnerable. Drought and increased climatic variability, including intense floods and storms, threaten Australia's endemic and depauperate freshwater fish communities (Allen *et al*. 2002; Pusey *et al*. 2004), which have large numbers of species of conservation concern (Lintermans 2010). Australian rainfall patterns and river flows are highly variable (Walker *et al*. 1995), complicating predictions of future changes (Lough and Hobday 2011). Australia's freshwater and estuarine fishes and their habitats have suffered considerable degradation in many regions (Gillanders *et al*. 2011; Morrongiello *et al*. 2011; Pratchett *et al*. 2011) and have been already affected by many other threats that have led to range reductions and reduced and fragmented populations.

Some considerations have already been given to climate-change impacts on Australian biodiversity (Lindenmayer *et al*. 2010), water resources (Bates *et al*. 2008) and the management of rivers and wetlands (Kingsford 2011). In particular, this has focussed on water management (Lester *et al*. 2011; Pittock and Finlayson 2011; Pittock and Hartman 2011), setting priorities (Crook *et al*. 2010) and developing adaptation strategies (Aldous *et al*. 2011). It is important that prioritisation be given to the management of species, locations and ecosystems judged to be most vulnerable to the impacts of climate change (see Koehn *et al*. 2011).

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Papers in this Special Issue

This Special Issue presents 12 papers that resulted from the Australian Society for Fish Biology conference symposium on 'Climate change and the aquatic environment: the future for fish and fisheries' held in Melbourne in July 2010. The symposium aimed to summarise the effects of climate change across freshwater, estuarine and marine habitats, and identify options for mitigation, adaptation and management in Australia. This cross-disciplinary approach covered all habitats and how they may be affected, discussing parallels and differences among ecosystems, their key attributes and the impacts on them (Koehn *et al*. 2011).

The papers in this Special Issue on climate change provide up-to-date knowledge and predictions, highlight priority areas for research and assess models for improved management adaptations for aquatic ecosystems, fish and fisheries in the Australian region. Current changes in climate are summarised by Lough and Hobday (2011), followed by modelled projections for Australian aquatic environments (Hobday and Lough 2011), range shifts for Australian fishes (Booth *et al*. 2011) and predicted freshwater fish distributions in response to climate change (Bond *et al*. 2011). Plagányi *et al*. (2011) describes an holistic approach to modelling ecosystems and their dependant Australian and Pacific communities. Direct impacts such as the effects of global warming and ocean acidification on fish reproduction and early life histories are explored (Pankhurst and Munday 2011), as are indirect impacts such as the changes to and loss of critical fish habitats, using the Great Barrier Reef and the Murray–Darling Basin as examples (Pratchett *et al*. 2011). Impacts and adaptations for Australian freshwater fishes (Morrongiello *et al*. 2011), aquatic ecosystems of the Murray–Darling Basin (Balcombe *et al*. 2011) and estuaries (Gillanders *et al*. 2011) will differ across populations, species and ecosystems, with some complex indirect impacts causing unexpected outcomes (Koehn *et al*. 2011).

Prognosis

Climate changes are evident in Australia and will be sustained and ongoing. They are already affecting fish and fisheries and there is a sense of urgency to recognise and manage these problems. Although there is a continuing need to raise political awareness of climate change and to take actions to reduce greenhouse gases, it is more important to undertake management actions to adapt to this changed climate regime. This management must be in conjunction with management for existing stressors, including fishery and water extraction.

We must accept that there are many uncertainties in the likely outcomes from this changed climate regime. Models can be used to help provide predictions and set priorities. Such models need to be based on the best available science and data, be adaptive and include fisheries, environmental, socioeconomic and political layers. Papers in this Special Issue aim to summarise the best available science on climate-change effects on fish and ecosystems of Australian freshwaters, estuaries and oceans to complement future effective management and modelling of this global crisis.

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