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Developing a climate adaptation strategy for vulnerable seabirds based on prioritisation of intervention options

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ABSTRACT

Conservation of marine species typically focuses on monitoring and mitigating demonstrated stressors where possible. Evidence is accumulating that some species will be negatively affected in the future by climate change and that reduction of existing stressors may not be sufficient to offset these impacts. Recent work suggests the shy albatross (*Thalassarche cauta*) will be adversely affected by projected changes in environmental conditions under plausible climate change scenarios. Furthermore, modelling shows that elimination of the principal present-day threat to albatrosses, fisheries bycatch, an achievable and critical priority, may not be sufficient to reverse projected population declines due to climate impacts, which cannot be directly eliminated. Here, a case study is presented in which a range of intervention options, in preparation for predicted climate change impacts, are identified and evaluated. A suite of 24 plausible climate adaptation options is first assessed using a semi-quantitative cost–benefit–risk tool, leading to a relative ranking of actions. Of these options, increasing chick survival via reduction of disease prevalence through control of vectors, was selected for field trials. Avian insecticide was applied to chicks' mid-way through their development and the effect on subsequent survival was evaluated. Survival of treated chicks after six weeks was significantly higher (92.7%) than those in control areas (82.1%). This approach shows that options to enhance albatross populations exist and we argue that testing interventions prior to serious impacts can formalise institutional processes and allow refinement of actions that offer some chance of mitigating the impacts of climate change on iconic marine species.

1. Introduction

Many iconic marine species are recovering from past harvesting activities (Croxall et al., 2012; Kirkwood et al., 2010; Leaper and Miller, 2011). While these species are now widely protected, management activities have tended to focus on reduction of existing stressors in an effort to increase population status to pre-exploitation levels (e.g. Croxall et al., 2012). For many species, a preserve-and-protect approach has been the primary strategy, which can work when individual threats can be removed, excluded or otherwise managed and the habitat for the species is otherwise of high quality (Croxall et al., 2012; Donlan and Wilcox, 2007; Schumann et al., 2013). Unfortunately, evidence is also accumulating that some iconic marine species and their habitat will be negatively affected by future climate change (Chambers et al., 2011; Poloczanska et al., 2009; Schumann et al., 2013). Thus, in the face of climate change, new approaches to population management may be required to complement continued focus on reduction of other stressors, including more directed intervention (Hobday et al., 2015; Mawdsley et al., 2009; Stein et al., 2013).

Intervention *per se* is not a new approach for conservation management. In a range of cases, particularly when populations decline precipitously, conservation biologists and managers have employed a range of interventions to manage threatened and endangered iconic marine species, including translocation where original habitat is no longer suitable or as a risk management strategy (e.g. Deguchi et al., 2014), invasive species control (e.g. Nogales et al., 2004), captive rearing and "headstarting" (e.g. Heppell et al., 1996) and habitat restoration (e.g. Priddel and Carlile, 2009). Lessons learnt from these experiences will help conservation managers, as many of these options may also be deployed in response to climate change, along with new approaches.

As for many terrestrial species, changes in distribution, abundance, physiology and phenology in response to climate change have been reported for marine vertebrates (Chambers et al., 2011; Schumann et al., 2013). In parallel with reporting of potential impacts, there have also been attempts to move from impact

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assessment to adaptation planning (Fuentes et al., 2011; Hobday et al., 2013; Mawdsley, 2011), in particular, to develop strategies to offset climate-related declines in endangered, threatened or protected species. For many marine species, particularly wide-ranging migratory species, development of realistic and effective intervention options is challenging (Heppell and Crowder, 1998; Hobday et al., 2013), and for practical reasons, interventions tend to focus on a land-based, typically breeding, phase if it exists. For example, conservation managers are investigating a range of strategies at marine turtle rookeries to offset declines resulting from impacts that are harder to address, including installation of fences to prevent nesting females falling off small cliffs (Great Barrier Reef Marine Park Authority, 2012), and consideration of strategies to reduce nest temperature (Jourdan and Fuentes, 2015; Wood et al., 2014). Provision of cooler artificial nest boxes for little penguins (*Eudyptula minor*) and underground placement of electricity cables to reduce fire risk are strategies that have been implemented to reduce the impacts of climate change (Chambers et al., 2011).

Before implementation, managers typically require conservation intervention strategies to have strong evidence-based support for likely effectiveness and feasibility, however, delaying action while scientific certainty is pursued is also problematic (Martin et al., 2012). Given the pace of climate change and the rate at which associated threats emerge and evolve, it is increasingly important to find an effective balance between obtaining perfect information and making decisions whilst there remains opportunity to act.

The standard sequence of knowledge acquisition typically involves detection of a clear impact signal, a subsequent effort to attribute that signal, followed by implementation of response options (adaptation) (Fig. 1). However, under this standard approach, and given the observed and projected rates of climate change, the environmental conditions under which the information was gathered may no longer exist when the adaptation commences. For effective and efficient conservation management therefore, this approach may need to be modified such that even without complete clarity regarding impacts and the causative agents, some adaptation options are tested and evaluated. This 'learning while doing' approach is consistent with adaptive management (Holling, 1978), but without discrete and sequential stages.

Such early intervention may require a change in philosophy for management agencies, particularly around climate change but in many cases an interventionist approach will already be employed in response to other issues, including captive breeding of threatened species (Martin et al., 2012), fire (Driscoll et al., 2010) and pest management (Raymond et al., 2011). However, perhaps due in part to the uncertainty associated with future climate scenarios, conservation agency responses to climate change are typically organised around monitoring and preserve-and-protect options (Gilfedder et al., 2012; Great Barrier Reef Marine Park Authority, 2007; Hagerman et al., 2010). While attempts to change values around intervention may be difficult (Wise et al., 2014), climate change and responding effectively to its impacts may necessitate rethinking of management paradigms (Hobday et al., 2013; Mawdsley, 2011; Prober and Dunlop, 2011).

Here we present an example of a strategic evaluation of adaptation options potentially available to managers to offset projected climate-related declines in the abundance of the Australian endemic shy albatross (*Thalassarche cauta*). This species is influenced by a range of historical and present day anthropogenic stressors (Alderman et al., 2011) and current management focuses upon ongoing conservation monitoring and reducing mortality associated with fisheries by-catch (Commonwealth of Australia, 2014; Department of Sustainability Environment Water Population and Communities, 2011).

The shy albatross population on Albatross Island in northwest Tasmania (40°22.634′S, 144°39.234′E) was harvested extensively in the late 1800s and underwent a steady population recovery over the next 100 years (Alderman et al., 2011). Although currently relatively abundant, with approximately 5200 annual breeding pairs, recent monitoring data show clear declines in annual breeding success and juvenile survival rates and population modelling suggests that climate drivers may lead to population declines in future (Thomson et al., 2015).

This system provides an opportunity to test adaptation options before the situation becomes critical, an approach seen as important by scientists and managers (Martin et al., 2012; McDonald-Madden et al., 2011). The long-term monitoring programme conducted on Albatross Island enables interventions to be evaluated in the context of observed and projected trends and supports a learning-by-doing approach.

To achieve the aim of this study, which was to evaluate, select and then trial intervention options that could be used to offset declines or enhance population status of shy albatross, we first identified a range of adaptation options, prioritised these based on semi-quantitative criteria and then selected one option for testing in the field. We present the process of evaluation and implementation of the preferred option, including initial results of the subsequent field trial. The emergent findings may also support development of direct conservation efforts for other species affected by a changing climate.

2. Methods

2.1. Selecting and prioritising adaption options

2.1.1. Development of adaptation options

A range of adaptation options to offset the negative impacts of climate change on shy albatross on Albatross Island were

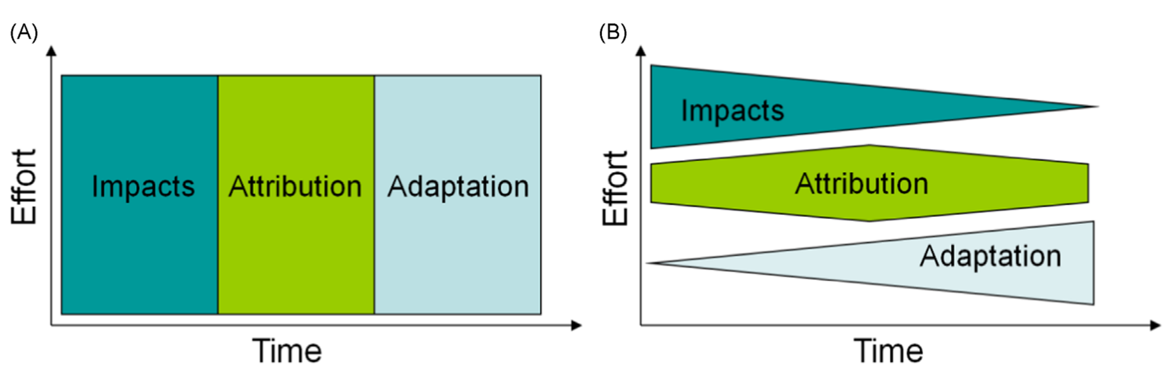

Fig. 1. (A) Traditional approaches to conservation management have an initial large focus on identifying and quantifying impacts, followed by an attribution phase in which the cause and effect is conclusively demonstrated, and then testing and implementation of adaptation options. (B) Parallel approaches may be more appropriate in a rapidly changing climate, with the height of the bars indicating relative effort.