



Research article

From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making

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ABSTRACT

Effective conservation requires knowledge exchange among scientists and decision-makers to enable learning and support evidence-based decision-making. Efforts to improve knowledge exchange have been hindered by a paucity of empirically-grounded guidance to help scientists and practitioners design and implement research programs that actively facilitate knowledge exchange. To address this, we evaluated the Ningaloo Research Program (NRP), which was designed to generate new scientific knowledge to support evidence-based decisions about the management of the Ningaloo Marine Park in north-western Australia. Specifically, we evaluated (1) outcomes of the NRP, including the extent to which new knowledge informed management decisions; (2) the barriers that prevented knowledge exchange among scientists and managers; (3) the key requirements for improving knowledge exchange processes in the future; and (4) the core capacities that are required to support knowledge exchange processes. While the NRP generated expansive and multidisciplinary science outputs directly relevant to the management of the Ningaloo Marine Park, decision-makers are largely unaware of this knowledge and little has been integrated into decision-making processes. A range of barriers prevented efficient and effective knowledge exchange among scientists and decision-makers including cultural differences among the groups, institutional barriers within decision-making agencies, scientific outputs that were not translated for decision-makers and poor alignment between research design and actual knowledge needs. We identify a set of principles to be implemented routinely as part of any applied research program, including: (i) stakeholder mapping prior to the commencement of research programs to identify all stakeholders, (ii) research questions to be co-developed with stakeholders, (iii) implementation of participatory research approaches, (iv) use of a knowledge broker, and (v) tailored knowledge management systems. Finally, we articulate the individual, institutional and financial capacities that must be developed to underpin successful knowledge exchange strategies.

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1. Introduction

The growing urgency and complexity of conservation problems present a significant challenge to managers and decision-makers (Sardar, 2010; Parrott and Meyer, 2012). Often described as ‘wicked problems’, these issues are characterised by high levels of uncertainty, contested values and political and administrative uncertainty (Hughes et al., 2013; Game et al., 2014). As a result there

have been calls for new flexible, integrated and evidenced-based approaches to management and governance that can holistically deal with the complexity of social-ecological systems and the goods and services they provide (Sutherland et al., 2004; Hughes et al., 2005; Mahon et al., 2008; Pahl-Wostl, 2009). Underpinning this is the extent to which conservation practitioners can access, interpret and integrate new scientific knowledge into decision-making processes via efficient and effective knowledge exchange among scientists and decision-makers (Cvitanovic et al., 2015a). In this regard, knowledge exchange is defined as the two-way exchange of knowledge between scientific ‘producers’ and ‘users’ (Mitton et al., 2007), and encompasses all facets of knowledge production,

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sharing, storage, mobilization, translation and use (Best and Holmes, 2010). Indeed, in the conservation and resource management sectors, knowledge exchange is increasingly recognised as a key factor facilitating the social, environmental and economic impacts of scientific research (reviewed by Fazey et al., 2013).

In recognition of the need to link conservation science to action, an emergent body of literature has sought to identify and overcome the barriers impeding knowledge exchange among scientists and decision-makers (e.g. Kareiva et al., 2002; Briggs, 2006; Shanley and López, 2009; Laurance et al., 2012; Cvitanovic et al., 2015b). Growing awareness of the importance of knowledge exchange has also led to increased efforts by conservation scientists and decision-makers to implement strategies that support knowledge exchange and lead to evidence-based decision-making (Pietri et al., 2011; Cook et al., 2013; Van der Molen et al., 2015). However, despite these efforts, recent evidence suggests that the integration of science into conservation decision-making processes remains a significant challenge (e.g. Cook et al., 2010; Cvitanovic et al., 2014a; Addison et al., 2015). As discussed by Reed et al. (2014), this is because while our conceptual understanding of knowledge exchange has advanced, there remains very little guidance to help scientists and decision-makers design and implement conservation research programs that actively facilitate knowledge exchange. As a result knowledge exchange activities are typically undertaken on an *ad-hoc* basis, with very little theoretical, methodological, or empirical grounding (Reed et al., 2014; Boschetti et al., 2016).

Developing guidance to help conservation scientists and practitioners design and implement research programs that actively facilitate knowledge exchange can be achieved through the evaluation of previous research programs that have attempted to link science to action (Meagher et al., 2008; Phillipson et al., 2012; Fazey et al., 2014; Reed et al., 2014). Such evaluations are necessary to elucidate the factors and processes influencing the effectiveness and efficiency of knowledge exchange activities (Connick and Innes, 2003; Dobbins et al., 2009; Laycock et al., 2011), and identify the core capacities required to support and facilitate knowledge exchange processes (Van Kerkhoff and Lebel, 2015). In this regard, capacities includes both the capability to act and the competences required to do so (Franks, 1999), and encompasses the full suite of individual, organisational, social, political, material, technical, practical and financial elements required to support knowledge exchange activities (Eade, 2007). Evaluations of knowledge exchange processes are seldom undertaken, however, given that successful outcomes are difficult to define and measure, and may occur sometime after a program has concluded (Fazey et al., 2013).

To develop empirically grounded guidance to help conservation scientists and decision-makers design and implement conservation research that actively enables knowledge exchange we undertook an extensive evaluation of the Ningaloo Research Program (NRP). Commencing in 2006, the NRP was an intense program of marine research valued at AUD\$36 m of funding, explicitly designed to generate new knowledge for the Ningaloo region in north-western Australia, so that conservation practitioners could make more informed decisions about the management of the Ningaloo Marine Park and surrounding area ahead of its nomination as a World Heritage Area in 2011. The program was large in scale and interdisciplinary in nature, with 40 individual research projects in four overarching themes; biodiversity, physical environment, socio-economics and human use, and management support tools.

In undertaking this evaluation of the NRP there were four primary research objectives. These were to evaluate the (1) program outcomes, including the extent to which the science generated through the program has subsequently informed management decisions; (2) the barriers that prevented efficient and effective knowledge exchange among scientists and managers involved in

the NRP; (3) the key requirements for improving knowledge exchange processes in the future; and (4) the core capacities that are required to support knowledge exchange processes. By focusing on a single conservation research program this study elucidates the perspectives and experiences of all program participants to provide a comprehensive and in-depth understanding of all of the factors that influenced knowledge exchange among conservation scientists and decision-makers. In doing so this study complements and builds upon Reed et al. (2014), who evaluated knowledge exchange activities across multiple research programs using a relatively small number of participants from each program. This approach also allows us to generate a set of key design principles to guide the development and implementation of future conservation research programs to enhance the related decision-making processes.

2. Methods

2.1. The Ningaloo region

The Ningaloo Region is home to the Ningaloo Marine Park, which encompasses Australia's largest fringing coral reef running 300 km along the coastline between Exmouth and Red Bluff. This area is a global biodiversity hotspot and in 2011 the Ningaloo Coast was inscribed on the World Heritage List in recognition of the 'outstanding universal value of the area'. The Ningaloo region is also a premier tourist destination and a key service point for oil and gas development and exploration, as well as supporting two permanent communities in Exmouth and Coral Bay. Given the multiple and competing uses of the region its conservation and management presents a significant challenge for decision-makers.

2.2. Data collection and analysis

To gather information relevant to the four objectives we used a qualitative research approach to develop an in-depth understanding of the experiences of participants in the NRP (Bryman, 2012). This involved conducting semi-structured interviews of participants recruited using a purposive snowball sampling technique between November and December 2016 (Noy, 2008). The initial group of participants was identified by the Science Coordinator responsible for the implementation of the NRP, who identified lead decision-makers and scientists involved in the program. At the completion of each initial interview, participants were asked to suggest others they believed would be relevant to the study, with this step being repeated at the completion of each subsequent interview. Any individual who was recommended more than once was invited to take part in the study. This approach yielded 24 names, three of whom were unable to be contacted as they had moved into new roles and their contact details were unknown. Thus, a total of 21 participants were interviewed: seven locally-based (Exmouth) decision-makers responsible for the day-to-day management and operation of the Ningaloo Marine Park, seven remotely-based (Perth) decision-makers involved in the long-term strategic decision-making associated with the management of the Ningaloo Marine Park, and seven chief scientists who led research activities within the NRP. The decision-makers spanned three different government agencies representing both State and local levels of government, and the seven scientists were from four separate Australian research institutions. For the purpose of analysis these groups were treated together as preliminary analysis showed no significant differences between their 'group' responses.

Prior to starting each interview, the purpose of the research was explained to the participant and formal written consent to participate was obtained (in accordance with Human Research Ethics procedures TSSHREC: H0015336). In general, each interview took

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