Ocean & Coastal Management 115 (2015) 49–60

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Challenges, insights and perspectives associated with using social-ecological science for marine conservation

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ARTICLE INFO

Article history:
Received 28 November 2014
Received in revised form
15 April 2015
Accepted 28 April 2015

Keywords:
Social-ecological systems
Sustainability science
Conservation
Natural resource management

ABSTRACT

Here, we synthesize conceptual frameworks, applied modeling approaches, and as case studies to highlight complex social-ecological system (SES) dynamics that inform environmental policy, conservation and management. Although a set of "good practices" about what constitutes a good SES study are emerging, there is still a disconnection between generating SES scientific studies and providing decision-relevant information to policy makers. Classical single variable/hypothesis studies rooted in one or two disciplines are still most common, leading to incremental growth in knowledge about the natural or social system, but rarely both. The recognition of human dimensions is a key aspect of successful planning and implementation in natural resource management, ecosystem-based management, fisheries management, and marine conservation. The lack of social data relating to human-nature interactions in this particular context is now seen as an omission, which can often erode the efficacy of any resource management or conservation action. There have been repeated calls for a transdisciplinary approach to complex SESs that incorporates resilience, complexity science characterized by intricate feedback interactions, emergent processes, non-linear dynamics and uncertainty. To achieve this vision, we need to embrace diverse research methodologies that incorporate ecology, sociology, anthropology, political science, economics and other disciplines that are anchored in empirical data. We conclude that to make SES research most useful in adding practical value to conservation planning, marine resource management planning processes and implementation, and the integration of resilience thinking into adaptation strategies, more research is needed on (1) understanding social-ecological landscapes and seascapes and patterns that would ensure planning process legitimacy, (2) costs of transformation (financial, social, environmental) to a stable resilient social-ecological system, (3) overcoming place-based data collection challenges as well as modeling challenges.

1. Introduction

There are a variety of conceptual models of social-ecological systems (SESs) that depict and characterize human-nature interactions in integrative ways (Young et al., 2006). These models are increasingly used in natural resource management and often in marine conservation (Xu and Marinova, 2013; Kittinger et al., 2013). As anthropogenic pressures have increased across all ecosystems, environmental sciences have undergone a paradigm shift in recent years, recognizing the crucial need to take into account human–nature relationships to better inform and guide conservation and management (Mace, 2014).

Consequently, SES studies have expanded dramatically during the last decade (Young, 2006; Xu and Marinova, 2013), revealing a growing interest from researchers and the public at large to understand SES dynamics and the sustainability of human-nature

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http://dx.doi.org/10.1016/j.ocecoaman.2015.04.018

interactions in terrestrial and marine environments (Liu et al., 2007a; Cinner et al., 2009b; Chapin et al., 2010; Diaz et al., 2011). Major scientific initiatives such as the Resilience Alliance (Folke et al., 2004), the Millennium Ecosystem Assessment (MA, 2005) and the establishment of the Sustainable Development Goals (SDGs) have provided comprehensive conceptual frameworks which link social and ecological systems. SES theories are based largely on the concept of resilience thinking (Gunderson and Holling, 2002; Hughes et al., 2005), which explores the dynamics and the organization of SESs, and their policy implications of SES contexts (Folke et al., 2004; Folke, 2006; Fischer et al., 2009; Deppisch and Hasibovic, 2011). For example, the Resilience Alliance has investigated SESs through a transdisciplinary lens with insights from complexity science (Holling, 2001; Berkes et al., 2003). Policy-relevant initiatives such as the Millennium Ecosystem Assessment (MEA) and Sustainable Development Goals (SDGs) are catalyzing meaningful research on ecosystem services and human well-being to fill a knowledge gap on the dynamics of human-nature interactions in SESs (MA, 2005). New scientific fields such as sustainability science (Kates, 2001, 2011; Clark, 2007; Bettencourt and Kaur, 2011) or land change science (Turner et al., 2007) have emerged from this thinking at the same time and also provided research and methodological guidelines for investigating SESs (Biggs et al., 2012a).

From this theoretical understanding, applied social-ecological science can provide case study approaches to investigations of place-based issues and can inform broader conservation and management (Parrott and Chion, 2012; Schlüter and Hinkel, 2014; Lowe et al., 2014). Ocean and coastal environments are complex adaptive SESs where social relationships of stewardship are diverse and resource use is most often unsustainable (Cinner et al., 2009b; Cinner, 2011, 2014; Kittinger et al., 2012, 2013). In marine environments, successful resource planning, therefore, requires diverse datasets and tools (Kittinger et al., 2014). Understanding how such complex adaptive systems are structured, evolve through time, respond to different pressures (e.g. environmental stressors, policy decisions, or management actions), and provide ecosystem services important for human wellbeing is crucial for social-ecological theory to inform marine conservation and management that produces long-term benefits for nature and people.

In this paper, we review the challenges of evolving social-ecological science towards applied outcomes to support resource management and marine conservation. We illustrate those challenges with insights coming from three distinct case studies. The paper has two main goals: 1) to elucidate the challenges of integrating social-ecological science into practical uses for natural resource management, conservation planning, and policy-making in marine ecosystems, and 2) to provide insights on how emerging transdisciplinary social-ecological science can best become an essential and practical decision-support tool in ocean spatial planning and conservation practice with clear linkages to how effective strategies for uptake into management and conservation can be developed. In effect, by unraveling marine environments as intricate peopled seascapes, social-ecological studies and resilience experts can unveil overlooked linkages in marine systems and provide paths to solutions (Kittinger et al., 2014). We base our review on a symposium workshop held during the International Marine Conservation Congress in 2014, as well as on emerging new research on the importance of social data in ocean and coastal environments.

2. The social-ecological challenges of marine conservation

2.1. From a transdisciplinary science to an interdisciplinary management

Transdisciplinarity – a research strategy that crosses disciplinary boundaries to create a holistic approach - is a prerequisite for investigations of SES properties or dynamics. For many years, the need for transdisciplinary collaborations in natural resource management and especially in marine conservation science had been underestimated (Christie, 2011; Fisher, 2012). However, complex marine conservation issues proved difficult to explore through the lens of a single discipline (Lade et al., 2013). Today, it is widely acknowledged that we need integrative approaches involving both social and natural sciences in order to capture a complete picture of complex SESs (Liu et al., 2007a; Ostrom, 2009; Carpenter et al., 2009). For example, transdisciplinary collaborations across biology, ecology, economics, geography, history, law, political science, anthropology, psychology, sociology and computer science can provide fundamental knowledge support for effective marine conservation and management (Carson et al., 2006; Clark, 2007; McDonald et al., 2008). However, while transdisciplinarity needs to be an academic endeavor, it is clear that interdisciplinarity is much more achievable in a management context (Fig. 1).

'Social-ecological system' is the commonly cited term in the scientific literature (Holling, 2001; Cinner et al., 2012d), but 'linked social-ecological systems' (Hughes et al., 2005), 'coupled human-environment systems' (Young et al., 2006), 'coupled human and natural systems' (Liu et al., 2007a) or 'social-environmental systems' (Diaz et al., 2011) are also used. The multiplicity of terms referring to the interplay of social and ecological systems reflects the different disciplinary fields and intellectual traditions within which the

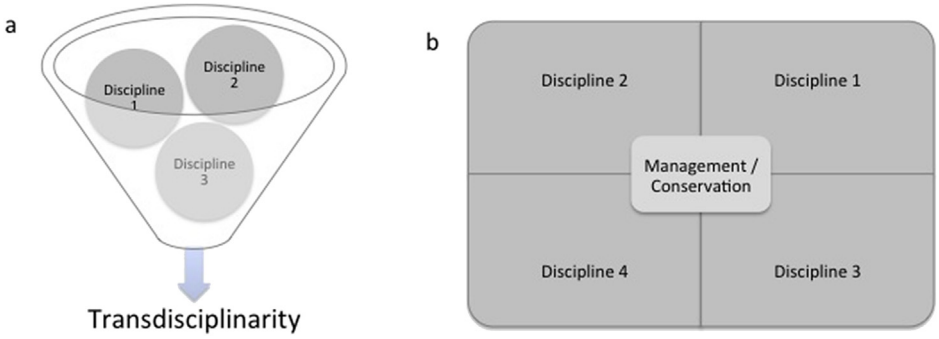

Fig. 1. a: Academic transdisciplinarity for the study of social-ecological systems. The academic way of creating a unified theory or concepts even before thinking about how this information may be useful or not for management. b: Interdisciplianrity or the reality of social-ecological conservation. Management objectives or conservation challenges require drawing out the most pertinent pieces of each discipline.