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Marine governance to avoid tipping points: Can we adapt the adaptability envelope?

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ABSTRACT

Combined pressures from climate change, resources demand and environmental degradation could lead to the collapse of marine systems and increase the vulnerability of populations dependent on them. In this paper an adaptability envelope framework is applied to investigate how governance arrangements may be addressing changing conditions of marine social-ecological systems, particularly where thresholds might have been crossed. The analysis focuses on three Australian case studies that have been significantly impacted by variations or changes in weather and climate over the past decade. Findings indicate that, in some cases, global scale drivers are triggering tipping points, which challenge the potential success of existing governance arrangements at the local scale. Governance interventions to address tipping points have been predominantly reactive, despite existing scientific evidence indicating that thresholds are approaching and/or being crossed. It is argued that marine governance arrangements need to be framed so that they also anticipate increasing marine social-ecological system vulnerability, and therefore build appropriate adaptive capacity to buffer against potential tipping points.

1. Introduction

Some marine systems may have already reached undesirable states or tipping points that impede their recovery. While tipping points associated with climate change are difficult to predict [1], as marine systems approach undesirable ecological states, significant social and economic implications will follow [2,3]. This may in turn lead to social-ecological tipping points given the interdependence between marine ecosystems and human communities [4].

As marine systems become more exposed to climate related impacts, improved governance interventions are needed to address the vulnerability of marine social-ecological systems and enhance their adaptive capacity to help offset the potential impacts [5]. In this paper, a framework based on the concept of an adaptability envelope is used to distil lessons from interventions implemented in three Australian marine systems affected by extreme events. Such extremes will become more significant under climate change, not only climatically, but also in their effect on marine social-ecological system vulnerability. To this end, the paper is structured in four parts. The first clarifies the concept of the 'tipping point' and its implications for marine governance. The second describes the adaptability envelope analytical framework with case studies. The third presents findings from the case study analyses. Finally, the paper concludes by discussing improved outcomes of equipping governance arrangements with capacities to respond to both ecological and social-economic tipping points, particularly those related to climate change impacts.

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2. Conceptual underpinnings: tipping points and adaptive governance

Irreversible shifts or tipping points have conceptual origins in the palaeoecological literature [6,7]. The application to systems theory recognises equilibria and irreversible change – where irreversible change occurs when thresholds may be crossed, between stability and instability, and can be caused either by external forces or internal loss of strength [8].

More recently, the terms, 'tipping point' and 'threshold' are used interchangeably within the literature concerning both biophysical and human systems, and are subject to varied interpretations [9]. This paper follows definitions from the fields of ecology and environmental governance.

In ecology, a tipping point is an ecological threshold beyond which the system may experience a major change in ecosystem properties such as habitat structure, species composition or community dynamics [10]. Ecological thresholds are understood as the points at which changes in external conditions can lead to significant change in the structure or function of the ecosystem [11]. Crossing ecological thresholds inevitably has implications for social systems, as ecological and social systems are interlinked [11,12].

In environmental governance, tipping points indicate the moment of crisis giving opportunities presented to governance systems to take action [13]. In this context, thresholds comprise the point at which decision-makers start to act in the policy context, such as the introduction of new legislation or allocation of financial resources to support specific policies. In social contexts, tipping points can be defined as a technical or social point in which an indicator shifts 'from an acceptable to an unacceptable condition' [14]. Although social tipping points are commonly discussed, specific evidence is limited [15], in part because their existence depends on subjective judgements about the style and scale of change [16].

Cases of social-economic collapse following ecological collapse are perhaps best documented in fisheries and forestry dependent communities [17]. However, social tipping points may also lead to ecological tipping points. For example, some Māori groups in New Zealand assert that the inability to utilise their fisheries management methods is linked to local fish stock declines [18,19]. Anticipatory adaptation (e.g., in relation to climate change) can also result in social tipping points being crossed. In particular, Crane [20] highlights how regional climate adaptation processes designed to build social-ecological resilience in lagoon fisheries resulted in dramatic social change for one group, but enabled another to thrive. Thus, while social tipping points may exist, their causation is often complex.

In summary, tipping points comprise irreversible shifts in a given system due to thresholds being crossed [1]. Once these thresholds are crossed, the system dynamics change and are irreversible even after attempts at returning variables to a pre-threshold state [1]. These radical shifts in system dynamics and structure are variously referred to as 'collapses' or 'regime shifts'. The standard criteria for their definition includes "sudden, high-amplitude, infrequent events, which are detectable in multiple aspects of the physical and biological components [of a system] and on large spatial scales" [21, p. 106].

2.1. Tipping points and adaptive governance

The literature identifies four key underlying causes that may contribute to unsuccessful marine governance responses when attempting to deal with tipping points. These include the setting of inappropriate quotas and rules [22]; the institutional inability to address intergenerational equity [23]; the focus on rights instead of responsibilities [22]; and the emphasis on short-term economic gain over scientific advice [24]. Conversely, successful marine governance responses often include flexibility to make context-specific rules [25]; decentralised, collaborative decision making that involves the local community [26]; effective trans-national governance and certification [27]; a move towards adaptive governance [28,29]; or shifting from open access to a zoned regime with specific rights and responsibilities [30].

Several important implications for adaptive governance can be identified in the literature on tipping points. First, a tipping point can induce a governance change and the transition to a more resilient social-ecological system [29,31] if a well-managed step by step process is followed [32–34]. Second, adaptive governance concerning tipping points requires the promotion of an integrated approach that involves multi-level spatial governance [35], has a multi-species/multi-ecosystem scope, considers market dynamics, and is led by community concerns [23]. Additionally, it also requires collaboration between government, business and the community [27], and supportive governance networks involving all stakeholders [36] leading to ethical collaboration [37,38].

Adaptive governance may be suitable to address marine system tipping points because its overall purpose is to steer societies as they develop the capacity to adapt and transform their interactions with natural systems and prevent them from tipping towards undesirable development trajectories. Adaptive governance is relevant in situations where transformative change is necessary because it focuses on the complex relationships between people and natural systems, interactions within multilevel institutional settings, key drivers of transformation, and a learning approach to managing change and uncertainty [17,29,39,40].

Dietz et al. [41] and Folke et al. [29] identified a range of conditions or requirements for adaptive governance. These can be encapsulated in adaptive governance principles of:

- *connectivity*, implying institutional ability to undertake timely and coordinated action across multiple scales and ensure timely information about feedbacks occurring within human-nature systems to avoid surprises;
- *adaptability*, suggesting the ability of governance structures to deal with change and reorganise if considered beneficial or necessary;
- *reflexivity*, implying governance arrangements encompassing abilities for awareness, deep reflection and recursive responsiveness to changing conditions that enables learning, new knowledge and feedback signals to be incorporated into adaptive management action; and
- *transformability*, involving the governance regime having potential to navigate a shift to a new system direction when the existing system becomes untenable.

Good adaptive governance combines these specific principles with traditional principles of good governance – legitimacy, accountability, transparency, fairness and inclusiveness [42].

3. Research approach and methodology

3.1. The adaptability envelope

Marine systems face multiple threats; vulnerability to climate change, combined with existing pressures, could lead to the collapse of marine systems, therefore requiring adaptive governance [43]. Vulnerability thresholds to climatic extremes are a consequence of the potential impacts from exposure and sensitivity, offset by any adaptive capacity in the system. The 'coping range' [44] of a system may be strengthened by adaptive capacity that