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Institutional misfit and environmental change: A systems approach to address ocean acidification

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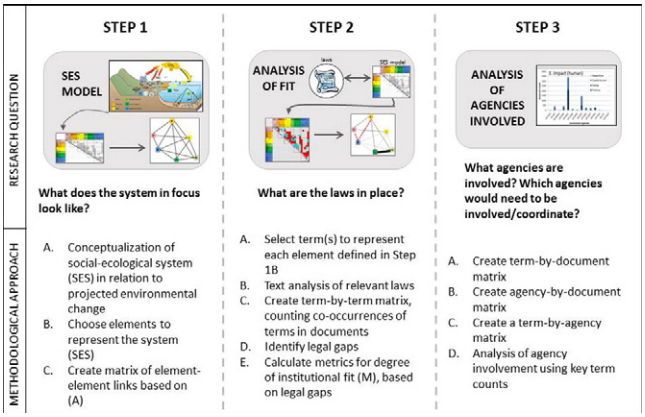
HIGHLIGHTS

- US laws show quantitative improvement in dealing with ocean acidification.
- The analysis brings a quantitative dimension to comprehensive legislative analysis.
- The results are consistent with governance literature verifying the utility of the approach.
- The method presented can be used to evaluate governance of a less understood issue.

GRAPHICAL ABSTRACT



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ABSTRACT

Emerging environmental threats often lack sufficient governance to address the full extent of the problem. An example is ocean acidification which is a growing concern in fishing and aquaculture economies worldwide, but has remained a footnote in environmental policy at all governance levels. However, existing legal jurisdictions do account for some aspects of the system relating to ocean acidification and these may be leveraged to support adapting to and mitigating ocean acidification. We refine and apply a methodological framework that helps objectively evaluate governance, from a social-ecological systems perspective. We assess how well a set of extant US institutions fits with the social-ecological interactions pertinent to ocean acidification. The assessment points to measured legal gaps, for which we evaluate the government authorities most appropriate to help fill these gaps. The analysis is conducted on United State federal statutes and regulations. Results show quantitative improvement of institutional fit over time (2006 to 2013), but a substantial number of measured legal gaps persist especially around acknowledging local sources of acidification and adaptation strategies to deal with or avoid impacts. We demonstrate the utility of this framework to evaluate the governance surrounding any emerging environmental threat as a first step to guiding the development of jurisdictionally realistic solutions.

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1. Introduction

Ocean acidification (OA) has emerged on the global environmental agenda as an issue of acute concern (Kerr, 2010). The rising acidity of both surface and deeper waters (Gruber et al., 2012) threatens to negatively impact a range of biological and biogeochemical processes (Beaufort et al., 2011; Orr et al., 2005) and significantly alter marine ecosystems (Fabry et al., 2008) which in turn underpin a wide array of marine ecosystem services (Cooley et al., 2009). OA is also forecasted to have complex interactions with multiple other stressors making predictions for outcomes and impacts on ecosystem services highly uncertain (Boyd, 2011).

Despite the apparent urgency of the issue and the role of the ocean in climate regulation, ocean acidification has remained a footnote in the development of climate change and related environmental policy at both international and national levels (Galland et al., 2012; Kim, 2012; Billé et al., 2013). While OA is a global concern, effects will be particularly discernable along coastlines characterized by upwelling or coral reefs. Such regional 'OA hotspots' therefore warrant not just a global, but a multilevel approach to governance. At the international level multilateral environmental agreements (MEAs) addressing OA are remarkably absent. Some have proposed that OA can be dealt with through UNFCCC, as both climate change and OA share the root cause of increasing CO_2 in the atmosphere (Doney et al., 2009) but others argue that UNFCCC does not provide an adequate legal framework as OA is not an effect of climate change and as such falls outside the UNFCCC's jurisdiction (Harrould-Kolieb and Herr, 2012; Kim, 2012). This absence of multilateral agreements for policy coordination among states observed for OA has been described as a nonregime (Dimitrov et al., 2007).

There are multiple reasons why nonregimes emerge, such as the fact that interactions are not well understood scientifically, the impacts may be felt locally while sources are global, and interventions are likely to interact with a range of other environmental and non-environmental institutions. Combined these create the conditions for a perfect collective action dilemma, diluting the incentives for sovereign states to act, individually or in collaboration (Galaz et al., 2012). OA is an issue domain that exhibits all three of these characteristics. A regime formation around the issue is therefore unlikely in the near future. Because of this and the regional distribution of initial OA effects (Strong et al., 2014), local and national governance options need to be explored in parallel with international efforts (Biermann, 2015; Galaz et al., 2012; Ostrom, 2010). This paper therefore examines the regulatory landscape relating to OA at the federal level of the US.

While sub-global levels may be better suited for developing adaptive responses, a key challenge remains: the problem of fit, referred to above (see Brown, 2003; Folke et al., 2007; Galaz et al., 2008; Young, 2008 for further discussion on the topic). Lack of fit between ecosystems and governing institutions (form hereon referred to as institutional gaps) has been the cause of significant environmental degradation worldwide (Barnes and McFadden, 2008; Folke et al., 2007). Given the novelty of OA as a policy domain, identifying institutional gaps is thus a first critical step in understanding the national governance landscape in place to address OA.

However, analytical tools for examining both fit and identifying solutions have remained sparse (Vatn and Vedeld, 2012; Epstein et al., 2015) with the exception of some recent developments (Guerrero et al., 2015; Lebel et al., 2013; Bodin et al., 2014; Treml et al., 2015). This paper addresses some aspects of this scholarly gap by providing an analytical framework for examining both ecological-institutional fit and the institutions potentially important in addressing lack of fit. We begin by outlining the analytical framework in more detail, including a brief discussion of OA from a social-ecological system perspective. Next we describe how a systems approach can be used to analyze ocean acidification-related governance for purposes of developing a policy resolution across sectors and ecosystems. We then elaborate the methodology and present the results in two parts; analysis of fit followed by analysis of agency involvement. We end with a discussion of the areas of poorest institutional fit and specific measured legal gaps needing policy attention now and provide some methodological reflections highlighting advantages and limitations of the approach.

2. Approach and methodology

The broad spectrum of drivers behind OA and human and environmental impacts suggests that an analysis of institutional fit and gaps needs to be based on a systems conceptualization of the problem. The benefit of the systems approach employed here (and described below) is that it identifies linkages between key relevant elements in the social-ecological system reflected in existing policy documents. Such links (or rather the legal documents representing them) may not currently be aimed at addressing OA (e.g. links between fisheries and tourism) but could nonetheless be a good starting points for tackling gaps in OA governance (Billé et al., 2013). Because social-ecological systems are not all the same any analysis must be tailored to the specific geographic region in focus. To allow us to make scientifically grounded conclusions we focus on the OA impacts related primarily to shelled mollusks and the potential repercussions and responses generally expected across the United States. Our motivation is that most biological evidence thus far points to shelled mollusks (larval stage) being severely affected by ocean acidification (Kroeker et al., 2013; Waldbusser et al., 2013; Talmage and Gobler, 2010). Several regions in the US are already seeing the effects of increased acidification, especially along the West and Northeast coast. Multi-million dollar losses are projected with repercussion for both ecosystems and livelihoods in the US (Kennedy, 2009; Cooley and Doney, 2009), and worldwide (Cooley et al., 2009; Brander et al., 2012; Narita et al., 2012; Narita and Rehdanz, 2016; Fernandes et al., 2016), making this a salient case to showcase our analysis.

The analytical framework has three parts; 1) building a model of a social-ecological system (SES) affected by a particular environmental change phenomenon, in this case OA; 2) identifying policy gaps associated with OA. This second step builds on methods developed by Ekstrom and Young (2009) developed in the context of marine policy and ecosystem based management (EBM). We show how this method can also be applied for other policy issues, such as OA, and how it can be used to assess regulatory development over time. 3) Thirdly we estimate which government organizations are responsible for implementing the regulatory instruments uncovered in step 2. This allows identification of the most likely barriers to institutional change by highlighting which organizations and legal instruments are currently involved and which may need to be involved in coordinating efforts to effectively prevent or alleviate further ocean acidification. Step 3 aims to provide a baseline of agency jurisdiction for the modeled SES system to assess the potential for filling the legal gaps through existing jurisdictions. Our focus is purely on jurisdictional and statutory issues, such as planning and mitigation, and as such does not address the issue of where future research funding should be directed for OA.

2.1. A framework for analyzing institutional fit and agency involvement

Fig. 1 outlines the proposed framework for analyzing institutional fit and agency involvement and its effects on a particular ecosystem. The analysis consists of three steps, each outlined in more detail below.

2.1.1. Step1: constructing a social-ecological systems model

The first step is to construct a social-ecological system model relating to, in this case, OA. The boundaries delineating our system of interest encompass both the sources of OA (carbon dioxide emissions, agriculture, urban development) all the way to expected responses of communities engaged in shelled mollusk fisheries and aquaculture. The utility of this systems conceptualization approach has been stressed by scholars aiming to integrate systematic and holistic analyses of sector-