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A step-wise process of decision-making under uncertainty when implementing environmental policy

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ABSTRACT

An ecosystem approach forms the basis of many recent environmental policies. The underlying concept states that decision-makers must consider the environmental, social and economic costs and benefits in the course of deciding whether to implement a management action. Decision-making can be undermined by uncertainty. Here, we discuss potential sources of uncertainty and their effect on an ecosystem approach-driven environmental policy, the factors affecting the choice and potential for management actions to achieve their objectives, the challenges associated with setting realistic and achievable targets, and how we can prioritise management of detrimental activities. We also consider how human challenges such as the availability of infrastructure and political will and ways of measuring costs and benefits and Member State interactions could also undermine environmental management. Potential limitations along with areas where further effort may be required to support ecosystem-based management objectives are highlighted and the advantages of a structured step-wise interdisciplinary approach to ecosystem management is shown.

1. Introduction

There has been a proliferation of environmental management policies in Europe and worldwide, many of which specify an ecosystem approach (Hassan et al., 2005). Environmental managers are obliged to consider the impact of a management action – an action primarily designed to improve ecosystem health – on existing social and economic systems (Samways et al., 2010). Moving from the aspirational objectives of an environmental policy to the implementation of management actions to effect ecosystem change requires decisions to be

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made with input (often independently) from environmental, social, economy and governance stakeholders, who make considerable effort to provide best available evidence. However, there is often uncertainty surrounding the evidence (Regan et al., 2005), and with greater uncertainty, there is an increase in the number of possible outcomes (Tversky and Kahneman, 1992) making decision-making more difficult, especially when time is limited (Haynes, 2009). In support, several frameworks have been developed for formal decision-making (see Regan et al., 2005 and references therein), but there remains little appreciation of how uncertainty can affect decision-making or how to deal with it.

The scale of the challenge facing ecosystem approach policies is reflected by the limited examples of implementation (FAO, 2005) and an even fewer number of success stories (Tallis et al., 2010). Nevertheless, the belief in the underlying concepts and potential benefits of the ecosystem approach is such that despite this, stakeholders have not been dissuaded from attempting to develop novel concepts and frameworks to support the ecosystem approach objective (although this process has primarily been driven by the scientific community). To date, efforts have been numerous and varied, ranging from complex (e.g. ecological networks, Oberle and Schaal, 2011) to more simplified approaches (e.g. cluster analysis, Knights et al., 2013).

Assessment frameworks often lead to the identification of several possible management actions to reduce the risk of environmental degradation from human activities (Knights et al., 2013; Piet et al., in preparation). Possible actions are then assessed *a priori* to determine which action (or combination of actions) is most appropriate for the given objective and should be taken forward. The most appropriate action(s) is not necessarily the best for the environment, society or the economy. Rather, appropriateness is a trade-off between the environment, societal and economic factors (Samways et al., 2010) as determined by the costs and benefits associated with a given action. Appropriateness can be assessed using a variety of tools (e.g. Hussain et al., 2010), but often and despite best intentions, any uncertainty that surrounds the evidence underpinning the management action can moderate the evidence-based decision (e.g. Nickerson and Zenger, 2002) such that there is a potentially inferior outcome for that action, and in the long-term, could affect the level of support for future action(s) (Bradshaw and Borchers, 2000).

In this paper, we discuss some sources of uncertainty and their potential effect on decision-making that is undertaken prior to or during the implementation of environmental policies that require an ecosystem approach. We use the Marine Strategy Framework Directive (Directive 2008/56/EC, MSFD herein) as a case study example to give recent context and to illustrate how uncertainty could affect the choice of the management action(s) that will be implemented, although the arguments themselves are generic and can be applied to other policies.

2. The Marine Strategy Framework Directive: a brief history

The MSFD established a framework obliging European Union Member States (MSs) to take the necessary measures to achieve or maintain Good Environmental Status (GES) in the marine environment by 2020. MSs have to develop and implement strategies that: (a) protect and preserve the marine environment, and (b) prevent and reduce inputs in the marine environment. The MSFD introduced 11 qualitative descriptors of the marine environment and outlined an objective for each (COM, 2010). Each objective delivers either maintenance or an improvement in the state of an ecological component (also referred to as characteristics), and a sustainable level of pressure exerted on the ecosystem by human activities that is compatible with GES. Ecological components include features such as biodiversity, fish and shellfish, or seafloor integrity, whereas pressures include underwater noise, marine litter and chemical contamination (see Annex I of the MSFD).

The MSFD sets out a roadmap for MSs (Articles 9 and 10), whereby they have to: (1) undertake an initial assessment of a set of ecological components of their water body, (2) identify the human activities that are exerting pressures which impact those components, (3) establish a comprehensive set of environmental targets and indicators to act as a guide for progress towards GES of regional seas, which when devised, (4) should take into account existing legislation (national, community or international), and (5) be mutually compatible with the targets of other MSs in their region. This roadmap can be visualised in a step-wise manner (Fig. 1), and here, we consider the challenges faced at each step and identify ways in which those challenges could be addressed. First, we discuss the factors affecting the potential for a management action to achieve its objectives assuming it is implemented and appropriately supported. This includes the role of 'non-manageable' environmental change such as climate change and the evaluation of anthropogenic 'manageable' change. We then discuss how human barriers to the implementation of management actions including the cost and benefit of a particular (suite of) measures, the availability of infrastructure, political will or policy inaction, and the interaction required between stakeholders during implementation. Potential limitations are identified and areas where further effort may be required to support ecosystem-based management objectives highlighted.

3. Identifying threats and risks to ecosystems, target setting and appropriate indicators

The likelihood of an environmental objective being met will be dependent on the ability of management action(s) to mitigate the impacts of human activities, where these are primary drivers of ecosystem state (Halpern et al., 2008). However, not all drivers of ecosystem state change are manageable (Fig. 2), but are having marked effects on ecosystems (Firth and Hawkins, 2011; Harley et al., 2006). A key step towards achieving ecosystem objectives must therefore be differentiation and quantification of the contribution of manageable and non-manageable drivers to ecosystem state, however uncertainty in the contribution of individual driver(s) to effect ecosystem state change can limit our ability to identify what should be managed, and what the impact of management might be.