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Accounting for the role of uncertainty in declining water quality in an extensively farmed grassland catchment

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ABSTRACT

Debate around the likelihood of achieving full compliance with Water Framework Directive objectives by 2027 has largely focused on the uncertainty in the lag-times between the implementation of mitigation measures and improvements in water quality. This paper examines uncertainties related to limited knowledge, predictability and ambiguity and their roles in declining water quality in Lough Melvin, a large lake in Ireland. Between 1991 and 2007 the total phosphorus (TP) concentration in the lake increased by 52%, raising concerns about eutrophication. Although agriculture in the catchment is extensive, operating at low stocking rates, it is estimated to contribute 62% of the TP load to the lake. Defining the reason(s) for this decline in water quality were hindered by sources of uncertainty in (1) understanding of farm practices; (2) understanding of the catchment hydrology; (3) monitoring and evaluation; and (4) farmer participation in agri-environmental schemes and policy implementation. Sources 1 and 2 contributed to the development of critical source areas of P in the catchment; source 3 reflects the accuracy both of water quality assessment and P source apportionment, and 4 played a part in the limited response to the observed changes in water quality. A number of approaches to overcoming these uncertainties are reviewed in the context of achieving the objectives of the WFD including: a catchment specific approach; stakeholder participation and critical appraisal of the decision – making processes for implementing the WFD.

1. Introduction

Since the implementation of the European Union (EU) Water Framework Directive (WFD) (2000/60/EC) the likelihood of achieving the standard of ‘good ecological status’ in impaired water bodies by 2027 has largely focused on the uncertainty in lag-times between the implementation of programmes of measures (POMs) and improvements in water quality (Fenton et al., 2011; Schulte et al., 2010). However, a wider debate is required as uncertainty extends to all components of science, policy and human behaviour, in problem identification, how problems are addressed, and how this information is translated into policy and action (Newig et al., 2005). Complexity, chaos, scale, transparency and inability to make observations are all causes of uncertainty in bio-physical environments, with Brown (2004) observing that in attempting to limit uncertainty, understanding ‘how we came to know’ is as important as ‘what we know’.

A number of authors have presented conceptualisations of uncertainty in water resource management, identifying the nature, type and sources of uncertainty (e.g. Raadgever et al., 2011; van der Keur et al., 2010; Isendahl et al., 2010).The nature of uncertainty is considered to be two fold;ontological (predictability) and epistemic uncertainty (incomplete knowledge) (Brugnach et al., 2008). Ontological uncertainty relates to

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the inherent variability in a system, for example in the case of diffuse phosphorus (P) pollution, the connectivity of hydrological pathways at catchment scale, while epistemic uncertainty concerns a lack of knowledge of the location of high P soils in a catchment. While epistemic uncertainty is reducible through the collection of data, ontological uncertainties are irreducible, although increased knowledge may improve predictability. Brugnach et al. (2008) concluded that the nature of uncertainty should also include ambiguity, which arises as a result of 'multiple knowledge frames' as to how a system is understood and managed. In this context, framing may refer to different perceptions on the cause of declining water quality (Isendahl et al., 2009). In the conceptual framework of Brugnach et al. (2008) these uncertainties are applied to three systems; natural systems (e.g. lake ecosystem); technical systems (e.g. mitigation measures) and social systems (e.g. decision-making processes).

The aim of this paper is to provide empirical evidence of the impact of uncertainty on the outcomes of water quality protection strategies in the Lough Melvin catchment, between 1991 and 2007. The paper reviews the impact of incomplete knowledge, predictability and ambiguity on water quality in the catchment based on the conceptual framework of Brugnach et al. (2008). Drawing on lessons from this case study, the paper discusses approaches to reducing decision-making uncertainties in the implementation of the WFD.

2. Catchment description

2.1. *Lough Melvin*

The catchment (220 km^2) of Lough Melvin (20 km^2) is almost equally divided between the Republic of Ireland (RoI) and Northern Ireland (NI) (Fig. 1). The diversity of its salmonid fish populations is unique amongst Irish lakes, with three subspecies of trout (*Salmo trutta* L.) and Arctic Char (*Salvelinus alpinus* L.), which is now extinct in almost all large lakes in Ireland (Campbell and Foy, 2008). The lake also contains Atlantic salmon (*Salmo salar* L.) which is an endangered species at a European level, and as a result the lake is designated as a Special Area of Conservation (SAC) under the EU Habitats Directive (92/43/EEC).

2.2. *Catchment management plan*

Investigations in 1991 and 2001 reported a large percentage increase in lake annual TP from 19 μg P L^{-1} (range 9–29 μg P L^{-1}) to 30 μg P L^{-1} (range 18–41 μg P L^{-1}) suggesting rapid enrichment of the lake (Girvan and Foy, 2006). In response a catchment management plan (CMP) was completed in 2008 which provided comprehensive data on water quality, landuse and threats to the lake and measures for lowering P inputs to the lake (Campbell and Foy, 2008). The CMP reported that lake TP had decreased to 27 μg P L^{-1} (range 10–45 μg P L^{-1}) with agriculture estimated to be contributing 62% of the P load in 2007. Detailed farm surveys were carried out as part of the CMP with data collected on the farming systems, the risk of P export at field scale and farmer's views and willingness to adopt specific mitigation measures. (Schulte et al., 2009).

The Lough Melvin catchment is typical of extensively farmed catchments in the west of Ireland (McGarrigle and Champ, 1999). Grassland and forestry account for 39% and 25% of the catchment, respectively, with the remainder consisting of upland heath. In the lowland areas agriculture is dominated by suckler (beef) cows which calve in spring, with summer grazing. Cattle are overwintered in housing for up to six months, and are fed grass silage, supplemented with feed concentrates. On the RoI side of the catchment, cattle increased by 23% between 1991 and 2000 and sheep numbers by 83%, likely due to EU farm payments which encouraged increased stocking rates. In 2005 this EU subsidy system was replaced by the single farm payment which is based on historic payments (pre, 2005) and not linked to current farm stocking rates. From 2000 to 2007 cattle numbers decreased by 31% and sheep by 42%.

Due to the cool temperatures and relatively wet soil conditions in northwest Ireland, grass yields in the catchment are low (Holden et al., 2004). In 2007 the average stocking

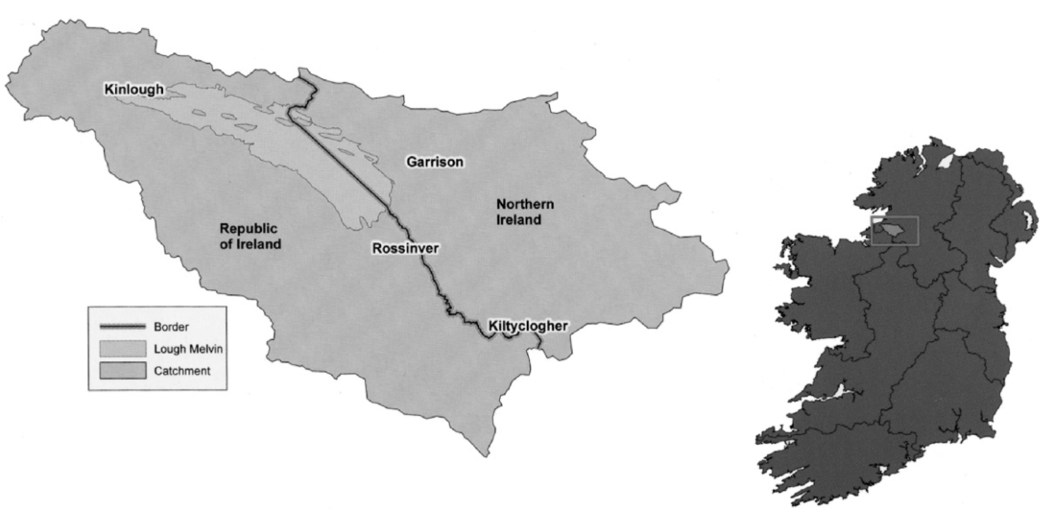

Fig. 1 – Location of the Lough Melvin catchment.