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Review

A hitchhiker's guide to European lake ecological assessment and intercalibration

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ABSTRACT

The Water Framework Directive is the first international legislation to require European countries to establish comparable ecological assessment schemes for their freshwaters. A key element in harmonising quality classification within and between Europe's river basins is an "Intercalibration" exercise, stipulated by the WFD, to ensure that the good status boundaries in all of the biological assessment methods correspond to similar levels of anthropogenic pressure. In this article, we provide a comprehensive overview of this international comparison, focusing on the assessment schemes developed for freshwater lakes. Out of 82 lake ecological assessment methods reported for the comparison, 62 were successfully intercalibrated and included in the EC Decision on intercalibration, with a high proportion of phytoplankton (18), macrophyte (17) and benthic fauna (13) assessment methods. All the lake assessment methods are reviewed in this article, including the results of intercalibration. Furthermore, the current gaps and way forward to reach consistent management objectives for European lakes are discussed.

Contents

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1. Introduction

Many benefits provided by aquatic ecosystems can only be maintained if the ecosystems are protected from deterioration (Millennium Ecosystem Assessment, 2005; de Groot et al., 2010). This aim requires (1) suitable methods to assess anthropogenic impact on aquatic ecosystems and to evaluate ecological integrity, (2) common management objectives across state boundaries and administrative barriers, and (3) concerted action aimed at halting and reversing degradation on the national and international level (Palmer et al., 2005; Hering et al., 2013).

Many countries have adopted legislation to determine the ecological integrity of surface waters including streams, rivers, lakes, estuaries and coastal waters. The purpose of the US Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Also in Australia, a broader, more holistic approach to aquatic ecosystem management is adapted "to maintain and enhance the ecological integrity of freshwater and marine ecosystems" (ANZECC, 2000). Similarly, the South African National Water Act aims at "protecting aquatic and associated ecosystems and their biological diversity". Still, in many cases, these legislation acts have not fulfilled their ambitions (Doremus and Dan Tarlock, 2013; Adler, 2013), mainly due to a lack of clear guidelines for the assessment of biological integrity (Davies and Jackson, 2006), the insufficient development and quality of bioassessment methods (Adler, 2003; Yoder and Barbour, 2009), a lack of consistent management objectives (Davies and Jackson, 2006; Adler, 2013), and poor comparability of biological data (Cao and Hawkins, 2011; Diamond et al., 2012).

In Europe, the Water Framework Directive (EC, 2000; WFD) establishes a framework for the protection and improvement of inland and coastal waters, which aims to achieve 'good' surface water status by 2015 or, at the latest, by 2027. In contrast to other legislations, the WFD provides operational definitions for assessing ecological status, setting management objectives, and harmonising EU Member States' ecological assessment systems. In short, the WFD is based on the following main principles:

- Biological assessment uses numerical measurements of communities of plants and animals (phytoplankton, aquatic flora, benthic invertebrates and fish fauna) as stipulated in the Directive (e.g., biomass, taxonomic composition, diversity, etc.).
- In biological assessment, the observed condition is compared with the reference status with the result given in five classes: 'high' status (no differences to reference conditions), 'good' status (slight differences), 'moderate' status (moderate differences), 'poor' and 'bad' statuses (major differences).
- 'Good' ecological status represents the target value that all surface water bodies must achieve in the near future. These values (expressed as 'good' status class boundaries) are compared and harmonised through the intercalibration exercise, ensuring consistent management objectives across Europe.

Since the adoption of the European Water Framework Directive (WFD) in 2000, huge progress has been made in the ecological assessment of European waters. Many European countries now have a set of assessment tools for indicating the state of Europe's water resources and for monitoring improvements in relation to investments in river basin management, or deterioration in response to future environmental changes (Birk et al., 2012a; Brucet et al., 2013b). These assessment methods are composed of several metrics (see Tables 1–5), and combination rules are applied to calculate the ecological assessment result for the whole system.

In order to harmonise ecological assessment systems and to ensure a consistent level of ambition in the protection and restoration of surface water bodies across the EU, an intercalibration exercise was launched, involving hundreds of experts from all Member States (Nõges et al., 2009). This exercise led to the development of innovative new approaches to accomplishing this highly complex task (Birk et al., 2013). In total, 230 methods from 28 countries were intercalibrated and published in the EC Decision (EC, 2013). This flagship document sets the harmonised boundaries for the Member States' national methods for classifying the ecological quality of their rivers, lakes, coastal waters and estuaries.

In this article, we provide an overview of this international comparison, focusing on the assessment schemes developed for freshwater lakes. More specifically, we (1) briefly review the assessment methods developed for lakes focusing on the metrics included and the pressures addressed; (2) describe the intercalibration exercise performed on lake assessment methods; (3) assess the gaps in the lake assessment methods regarding biological communities, pressures addressed and geographical regions.

2. Intercalibration methodology

A step-by-step methodology for the comparison and harmonisation of ecological assessment methods was developed (EC, 2011; Birk et al., 2013). The assessment methods were first checked for their compliance with the WFD requirements - only methods that