Comparability of fish-based ecological quality assessments for geographically distinct Iberian regions

P. Segurado [a,*], N. Caiola [b], D. Pont [c], J.M. Oliveira [a], O. Delaigue [c], M.T. Ferreira [a]

[a] Forest Research Centre, Agronomy Institute, University of Lisbon, Lisbon, Portugal
[b] IRTA Aquatic Ecosystems, Sant Carles de la Ràpita, Spain
[c] Irstea, UR HBAN, 1 rue Pierre-Gilles de Gennes, CS 10030, 92761 Antony, France

HIGHLIGHTS

- We compared the river fish ecological quality indices of the two Iberian states.
- The two indices were intercalibrated indirectly using a pan-European index.
- The three indices were responsive to the same set of individual pressures.
- Despite high spatial turnover of species, boundary harmonization was accomplished.

ARTICLE INFO

ABSTRACT

In this work we compare two Iberian and a pan-European fish-based methods to assess ecological quality in rivers: the Fish-based Index of Biotic Integrity for Portuguese Wadeable Streams (F-IBIP), the Mediterranean Index of Biotic Integrity (IBIMED) and the pan-European Fish Index (EFI+). The results presented herein were developed in the context of the 2nd phase of the Intercalibration Exercise (IC), as required by the Water Frame Directive (WFD). The IC is aimed at ensuring comparability of the quality boundaries among the different WFD assessment methods developed by the Member States for each biological quality element. Although the two national assessment methods were developed for very distinct regions of Iberia (Western and Eastern Iberian Peninsula) they share the same methodological background: both are type-specific and guild-based multimetric indices. EFI+ is a multimetric guild-based model, but it is site-specific and uses a predictive modelling approach. The three indices were computed for all sites included in the Iberian Intercalibration database to allow the direct comparison, by means of linear regressions, of the resulting three quality values per site. The quality boundary harmonization between the two Iberian methods was only possible through an indirect comparison between the two indices, using EFI+ as a common metric. The three indices were also shown to be responsive to a common set of human induced pressures. This study highlights the need to develop general assessment methods adapted to wide geographical ranges with high species turnover to help intercalibrating assessment methods tailored for geographically more restricted regions.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

The use of a common scale among the EU Member States (MS) to assess the ecological status of the European rivers is a primary requirement for the implementation of the Water Frame Directive (WFD; European Commission, 2000). Indeed, the final goal of the WFD, i.e. to achieve "good" ecological status of all surface waters by 2015, should necessarily have the same ecological meaning across the several MS involved. Therefore, the implementation of the WFD depends upon the harmonization of the classification boundary between "moderate" and "good" ecological status among the national assessment methods of all MS. This harmonization process is referred to in the WFD as the intercalibration exercise (IC) (Birk et al., 2013).

Because of natural, cultural and socio-economic regional differences, as well as a multitude of scientific perspectives among researchers, there are many differences among the biological assessment methods adopted by each MS. However, the WFD is flexible regarding the methodological details of the assessment systems adopted by each Member State, as long as a few general principles are followed. Hence, the purpose of IC is not to harmonize assessment methodologies, but only their outputs. However, assessment systems that measure very different kinds of disturbance will most likely be more difficult to harmonize than assessment systems that were developed to respond to common or related disturbances.

* Corresponding author. Tel.: +351 213653380; fax: +351 213653338.
E-mail address: psegurado@isa.utl.pt (P. Segurado).

Even though the first methods to assess the biotic integrity of rivers were developed specifically for fish (e.g., Karr, 1981; Fausch et al., 1984), so far, published studies on the issue of intercalibration of river assessment methods have been primarily focused on macroinvertebrates (Buffagni et al., 2005; Bennett et al., 2011; Birk and Hering, 2006, 2009), macrophytes (Birk et al., 2006; Birk and Willby, 2010) or diatoms (Birk and Hering, 2009). However, fishes not only possess a higher direct socio-economic impact than other aquatic organisms but are also key indicators of biotic conditions of rivers since, in comparison with other taxa, they tend to be more responsive to hydromorphological disturbances (Birk et al., 2012; Marzin et al., 2012), connectivity loss (Schiemer, 2000; Sindilariu et al., 2006) and other stressors acting at wider spatial and temporal scales (Harris, 1995; Simon, 1999). Even so, in Europe, when WFD was implemented, only a few MS had developed national assessment methods based on river fish. As a consequence, the pilot IC exercise of fish-based river assessment methods carried out in 2006 was largely hampered (Jepsen and Pont, 2007). This exercise involved 22 MS, including the two Iberian countries (Portugal and Spain). Since then, many MS – namely from the Mediterranean basin – have been making an effort to develop and improve new fish-based river assessment methods.

Several attributes of fish assemblages from the European Mediterranean basin are referred to as major bottlenecks for the development of fish-based assessment methods to evaluate river quality in this region, namely, (1) the low levels of alpha diversity, (2) a high degree of endemicity and basin-specific assemblages, (3) the lack of sound information on life history traits and ecological requirements for many species, (4) an innate tolerance to naturally harsh and fluctuating environments displayed by many species, (5) the significant intra- and inter-annual variability in fish assemblage structure, and (6) a general scarcity of pristine sites to be used as reference conditions (Moyle and Marchetti, 1999; Ferreira et al., 2007a; Magalhães et al., 2008; Hermoso et al., 2010; Aparicio et al., 2011).

Although several attempts have been made to develop a common biotic integrity index at the Mediterranean scale, they were hindered by weak metric responses to human impacts at this large scale or to inconsistencies among the highly diverse fish assemblages (Ferreira et al., 2007a; b; Segurado et al., 2008). This failure suggests that more specific adaptations may be needed at more restricted spatial scales, for instance at the watershed level or fish river-type (Magalhães et al., 2008). Indeed, several fish-based indices at smaller regional scales have been developed and tested with success (e.g. Sostoa et al., 2004 2010; Magalhães et al., 2008; Hermoso et al., 2010; Aparicio et al., 2011; INAG and AFN, 2012).

The first attempts to develop fish-based methods across the whole European Mediterranean basin were made within the EU-funded FAME and EFI+ projects (http://fame.boku.ac.at; http://efi-plus.boku.ac.at/index.htm). The main output of these two projects was the European Fish Index (EFI+), the first standardised fish-based assessment method applicable across nearly the whole range of European rivers (Pont et al., 2006, 2007). Although this pan-European Fish Index was reasonably accurate at the European scale, its applicability varied among different biogeographical regions and countries (Pont et al., 2007; Urbanic and Podgornik, 2008; Logez et al., 2010).

Nevertheless, an important potential applicability of the EFI+ was also its use as a common metric in the intercalibration exercise, i.e., to bridge between assessment systems of different member states. This potential role would be especially relevant for the Mediterranean region where, as mentioned above, important regional differences in fish assemblages and their response to disturbances occur.

In this study we compared the fish-based assessment methods of the two Iberian member states (Portugal and Spain) and evaluated whether the EFI+ index is a valuable tool to link the two methods to a common scale. This study is partially based on research conducted during the 2nd phase of the intercalibration exercise, carried out from 2008 to 2011, under the WFD Common Implementation Strategy coordinated by the European Commission's Joint Research Centre (JRC). More specifically, the study describes part of the research undertaken by the Mediterranean and South Atlantic regional subgroup of the River Fish Intercalibration Group (Pont, 2011).

2. Material and methods

2.1. Fish-based assessment methods

TTwo national methods and one pan-European method to assess the quality of running waters based on fish fauna were compared in this study. All were based on the reference condition concept (Pardo et al., 2012) and used metrics derived from several functional attributes of fish assemblages (guilds). The three methods met the WFD-compliance criteria, more specifically: 1) the methods were in line with the boundary setting procedure, classifying ecological status according to five quality classes, 2) all relevant parameters of the biological quality element were covered, and 3) methods addressed the same common river type(s) and anthropogenic pressure(s), and followed a similar assessment concept adapted to the river types defined in the intercalibration exercise.

2.1.1. Fish-based Index of Biotic Integrity for Portuguese Wadeable Streams (F-IBIP)

The F-IBIP is a multimetric index based on reference condition criteria (INAG and AFN, 2012). The metrics are based on parameters derived from fish assemblage composition and ecological functional groups (guilds) and differ among six fish-based river types, distinguished by a set of abiotic variables that were the most relevant for fish: altitude, mean July air temperature, drainage area, mean annual rainfall, and a geographical categorical variable indicating whether the site is located to the North or South of River Tagus. The classification of each site into a river type was determined through use of a discriminant analysis classification function based on the values of each environmental variable. The overall misclassification rate was 0.18. A total of six river types were defined: Type 1 — Northern salmonid streams; Type 2 — Northern salmonid–cyprinid transition streams; Type 3 — Northern-interior medium-sized cyprinid streams; Type 4 — Northern-interior/Southern small-sized cyprinid streams; Type 5 — Southern medium-sized cyprinid streams; Type 6 — Northern-coastal cyprinid streams.

Candidate guild-based metrics were included on six functional attributes: species composition, general tolerance, trophic function, habitat preference, reproductive classification, potamodromy and age structure. For each fish-type, metrics were filtered according to: (1) the range of their value distributions was examined using graphical analysis, eliminating metrics with very narrow value ranges; (2) their discrimination power between the group of reference sites and the group of non-reference sites using Mann–Whitney test; (3) their responsiveness to single IMPRESS (impacts and pressures) variables using Spearman correlation coefficients; (4) their relationship with the natural variability that could obscure potential fish response to pressures, based on linear regressions of each metric against each natural gradient (catchment size, stream slope, and altitude) at reference sites; and (5) their redundancy, based on Spearman correlations using reference sites only. A total of twelve metrics were selected to compute the F-IBIP for all river types: Number of native species, Number of intolerant and intermediate species, % alien individuals, % intolerant individuals, % intolerant and intermediate individuals, % intolerant and intermediate Cyprinid species, % omnivorous individuals, % invertivorous individuals (excluding tolerant species), % potamodromous individuals, % reproductive generalist and "non-spawner" individuals, % lithophilic individuals and % water column individuals (native species).

Metrics were scored separately by fish-type on a continuous scale from 0 to 1. For metrics negatively correlated with pressure, the floor