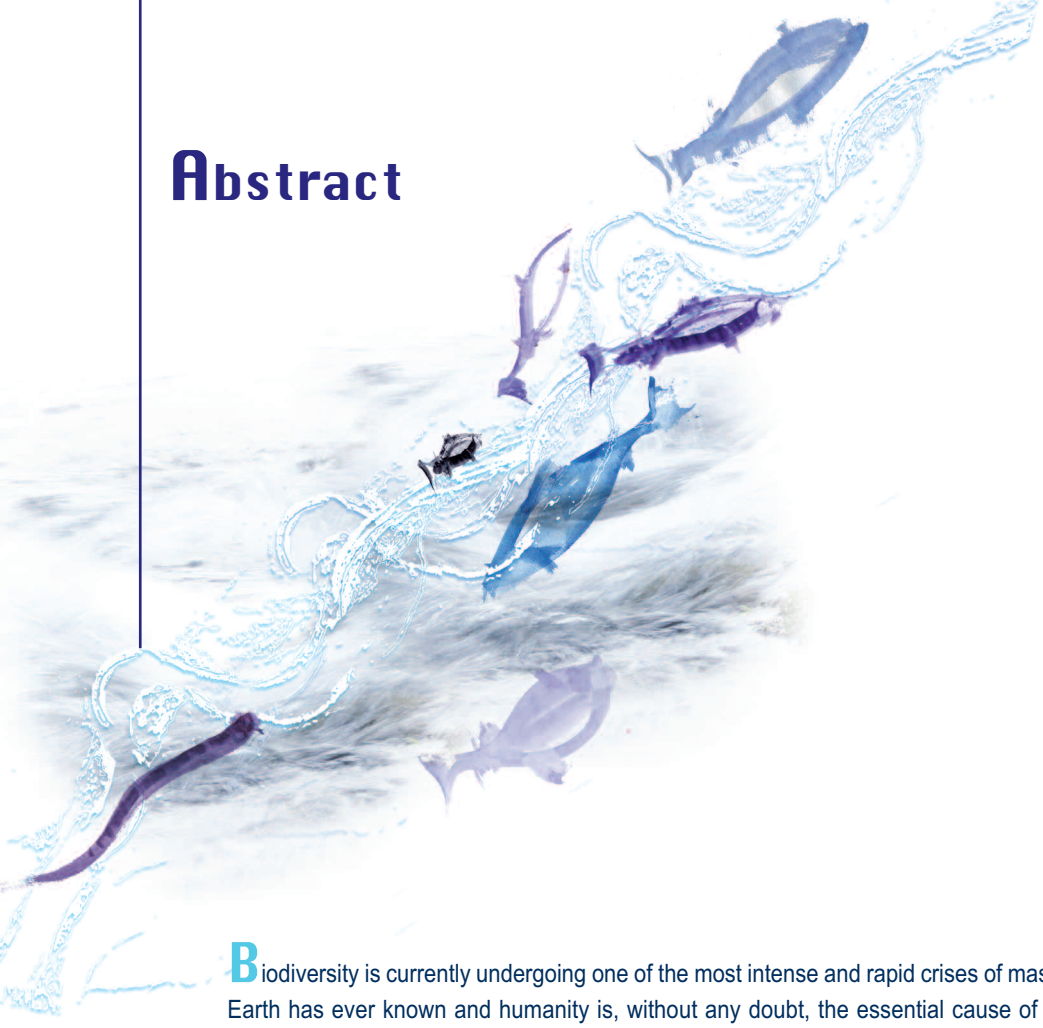
Abstract



Biodiversity is currently undergoing one of the most intense and rapid crises of mass extinction that the planet Earth has ever known and humanity is, without any doubt, the essential cause of the drastic losses. Among the many factors are chemical pressures in the form of water, soil and air pollution as well as in the form of climate change, excessive use of natural resources (hunting, fishing, cutting of forests, etc.), and physical pressures such as the destruction or loss of access to the habitats required by numerous species for their survival. The impact of physical pressures and in particular the fragmentation of habitats is today better understood and has been amply demonstrated. The international community has progressively acknowledged this issue and responded with a number of legal texts. In the European Union, the Water framework directive (WFD) is a prime example. The objective of the texts is generally to preserve and to restore ecological continuity and ecological corridors in order to slow or to stop at least part of the loss of biodiversity now taking place.

Before taking action in favour of ecological continuity, it is necessary to assess the degree to which natural areas have been modified and to identify the situations creating the greatest problems. In aquatic ecosystems, hydraulic structures are one of the main causes of degraded ecological continuity, particularly for fish whose survival depends on their freedom of movement. An assessment of the impact of structures on the movement of fish is a prerequisite to determining the seriousness of problems in the field and identifying the priorities for action.

To date, these assessments have generally been carried out by a small number of highly specialised experts. However, the massive (yet often unsuspected) numbers of transverse obstacles on rivers (over 70 000 obstacles have already been inventoried in France thanks to the characterisation reports for the WFD) created a pressing need for a simple, robust and standardised method for assessments that could be used by a large number of persons active in the environmental and territorial-planning fields.

Onema responded to the challenge and coordinated the development of a protocol to assess the impact of obstacles to flow on the movement of the main fish species in continental France.

This *Knowledge for action* document presents the results of that work, namely the ICE protocol designed to produce information on ecological continuity in rivers.

This document is divided into four main chapters.

- **Based on a review of the current scientific knowledge on the international level, it discusses the importance of ecological continuity for fish.** Chapter A looks at the bio-ecological issues involved in the free movement of fish and at the various methods of overcoming obstacles used by species in continental France. Passage of obstacles depends on major environmental factors, on the ethology of species as well as on the physical capabilities of each species. The methods used to determine the physical capabilities are presented, as are the main conditions limiting passage of obstacles. The chapter also discusses the main types of physical barriers and their impacts on fish populations.

- **The document describes the general principles underlying the ICE protocol.** Chapter B addresses the basic concepts and the general implementation procedure for the method, and presents a typology of the main obstacles analysed by the protocol. In addition, it lists eleven ICE species' groups according to their physical capabilities in overcoming obstacles as well as five "passability" classes intended to inform on the impact of obstacles.

- **It presents in detail the protocol implementation method and assists readers by delving into each step of the procedure to assess the passability of obstacles during upstream migration.** Chapter C goes into the calculation method for the indicators on each of the five major types of obstacle discussed. It does not neglect the special case of the European eel, which has some very specific movement techniques. All topographical and hydraulic constraints are taken into account and hydrological variations are also included to assist in defining the assessment strategy. Each procedure is presented as a flow chart to assist in decision-making, thus making the protocol easy to use for a wide range of people.

- **The document also addresses the special case of obstacles equipped with a fish pass.** Chapter D lists and describes various types of fish passes that are commonly found in France. It discusses the main causes of malfunctions and proposes a rapid, pre-assessment method to determine their performance level.