FHARMOR: Fish Habitat in Alpine Rivers – Integrating Monitoring, Modelling and Remote sensing

L'habitat du poisson dans les rivières alpines - Intégrer la surveillance, la modélisation et la télédétection

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RÉSUMÉ

De nos jours, les modèles d'habitat à méso-échelle sont largement utilisés pour quantifier l'impact des pressions hydromorphologiques qui s'exercent sur les cours d'eau. Cependant, l'application de ces modèles est entravée par plusieurs facteurs : 1) La cartographie de mésohabitats est limitée dans les rivières infranchissables à pied ; 2) L'obtention de valeurs d'écoulement précises est un procédé lent et difficile car nécessitant une cartographie de l'habitat pour chaque débit ; 3) Les variations d'habitat engendrés par des événements extrêmes et l'influence de la morphodynamique à moyen-terme ne sont pas pris en compte. L'objectif du projet FHARMOR est de surmonter ces limites en étudiant des techniques complémentaires aux mesures in situ ainsi qu'aux modèles hydromorphodynamiques et aux techniques de télédétection. Ces techniques sont à l'essai dans plusieurs études de cas présentant des caractéristiques hydromorphologiques typiques de la région centre-nord des Alpes italiennes i.e. la Mareit, l'Ahr et l'Eisack. Les résultats attendus de FHARMOR sont les suivants : 1) Evaluer quantitativement et au moyen de cadres méthodologiques compréhensibles la dynamique de l'habitat du poisson dans des rivières de différentes tailles de la région alpine et sur de grandes étendues ; 2) Création de scénarios futurs sur le potentiel de développement d'habitats dans les rivières alpines par rapport à la réhabilitation de rivières et la gestion des sédiments.

ABSTRACT

In recent times, habitat models at the meso-scale have become widely accepted techniques to quantify the impact of hydro-morphological pressures on rivers. However, several limitations limit a broader applicability of such models: 1) field-based mesohabitat mapping is difficult in large non-wadable streams; 2) obtaining a reliable habitat-streamflow rating can be a highly time-consuming process, since it requires field mapping over many discharges; 3) the role of event-scale and medium term river morphodynamics, a crucial source of habitat variability, is mostly not accounted for. In this work we present the FHARMOR project, which aims at overcoming the above limitations, by exploring the application of complementary techniques to ground field measurements of mesohabitats, namely hydro-morpho-dynamic modeling and remote sensing techniques. This is tested on a suite of case studies featuring a gradient of hydro-morphological characteristics and channel size, located in the central-north Italian Alpine area, i.e. the Mareit/Mareta, the Ahr/Aurino and the Eisack/Isarco rivers. The expected outcomes from the FHARMOR project are: 1) a quantitative, comprehensive methodological framework able to effectively quantify fish habitat dynamics in Alpine river systems of different size and over long reaches; 2) future scenarios development of habitat availability in Alpine rivers in response to sediment management and river restoration.

KEYWORDS

Alpine rivers; hydromorphological modeling; non-wadable river; mesohabitat; remote sensing

1 INTRODUCTION

Alpine rivers are highly affected by hydro-morphological alterations caused by human interventions like damming of rivers, water diversions, sediment mining, and which are causing strong impacts on freshwater ecosystems. Meso-scale habitat models have become widely accepted to quantify the impact of hydro-morphological pressures and of river restoration measures, as well as to support the planning phase of water resources management through the design of environmental and ecological flows.

Mesohabitat modelling (Parasiewicz 2007, Vezza et al. 2014) shows potential in relating habitat availability to river morphology and to the flow regime. Furthermore, it allows to integrate a wide range of abiotic and biotic environmental variables (e.g. vegetation, cover, connectivity, woody debris), in the physical description of the river system, which is otherwise limited by a restrictive choice of variables (velocity, depth and substrate) used in habitat models based on a “microscale” approach.

Despite their potential, several factors still limit a broader applicability of meso-scale habitat models:

1) Field-based mesohabitat mapping is difficult in large streams, that are non-wadable even under low flow conditions;
2) Mesohabitat mapping needs to be performed under the broadest range of streamflow values, to obtain a reliable habitat-streamflow rating curve for a river reach, which can be highly time-consuming and limits the number of reaches where the methodology can be applied;
3) Most of the available studies for river habitat dynamics do not account for the role of event-scale (disturbance) and medium term (trajectory) river morphodynamics which reset the habitat template and thus are a crucial source of habitat variability.

2 METHODOLOGY AND CASE STUDIES

In this work we present the FHARMOR project, which aims at overcoming the above limitations, by exploring the potential of complementary techniques to ground field measurements of the hydro-morphological units, namely hydro-morpho-dynamic modeling and remote sensing techniques, including bathymetric LIDAR and hyperspectral imagery.

Airborne LIDAR systems allow high-resolution measurements of the river’s bathymetry, by using a water penetrating laser system to survey the ground. UAV-based hyperspectral imageries can be used to estimate river habitat attributes, such as vegetation and substrate type. From this information a hydrodynamic model can be set up, whose outputs can be used to estimate meso-habitats, i.e. hydro-morphological-units, such as pools, riffles and runs (Hauer et al. 2009), by using “unsupervised” or “semi-supervised” statistical techniques (e.g. clustering).These techniques are being tested on a suite of case studies featuring a gradient of hydro-morphological characteristics and channel size, located in the central-north Italian Alpine area, i.e. the Mareit/Mareta, the Ahr/Aurino and Eisack/Isarco rivers (see Fig 1).

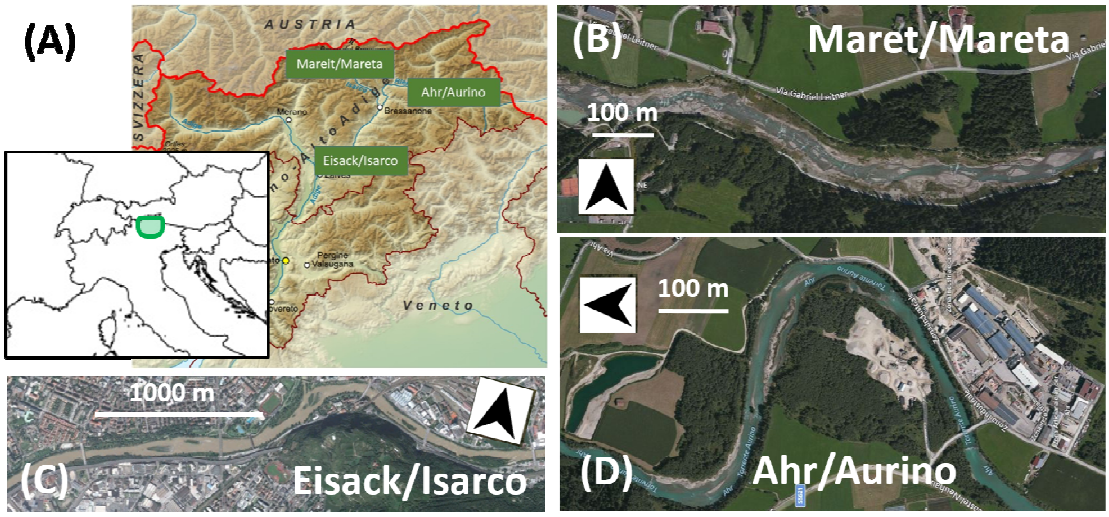

Fig 1: (A) Location and (B,C,D) aerial view of the FHARMOR project’s case studies

All selected study reaches underwent or are currently undergoing river restoration projects. A 3km long reach of the Mareit/Mareta was restored to a braided morphology in 2009 by removal of all check-dams and bank protections. The Ahr/Aurino river, that mostly presents a single-thread, sinuous to meandering channel fixed by bank protection and levees, was partly restored starting in 2003, with actions aimed mainly at improving riparian woodlands and fish habitat. The Eisack/Isarco river is the largest and most regulated among the case studies, both in terms of hydrological regime (hydropeaking) and of morphological characteristics, being rectified, embanked and subject to frequent cuts of riparian vegetation. Starting from 2015 a long-lasting morphological restoration project is under way, with the aims to diversify habitats and improve fish communities.

3 OUTCOMES

Three main outcomes are expected from the FHARMOR project.

First, the potential of hydro-morpho-dynamic modeling and remote sensing techniques to predict the spatial and temporal patterns of meso-scale fish habitat will be assessed. While hydro-morphodynamic modelling has been widely employed within micro-scale habitat models, its use at the mesoscale is still in its infancy (e.g., Fig. 2A). FHARMOR will focus on the ability of hydrodynamic models to reproduce observed meso-habitat rating curves, and to extend the range of their validity to non-wadable discharge conditions. Assessment of how the input resolution of river geometry affects this results, and how multispectral imagery information can be integrated into the analysis of meso-habitats will also be investigated.

The project also foresees to develop a quantitative, comprehensive methodological framework (Fig 2B) able to effectively quantify fish habitat dynamics in Alpine river systems of different size and over long reaches, in a form that can be easily used by river managers and integrated into existing methods for hydromorphological and ecological status assessment.

The framework will be used to develop future scenarios of habitat availability in Alpine rivers in response to sediment management and river restoration, specifically on the chosen case studies, which feature a wide set of restorative actions. This shall allow predicting the range of possible changes in habitat dynamics as a consequence of river restoration projects, such as local river widening or gravel augmentation measures.

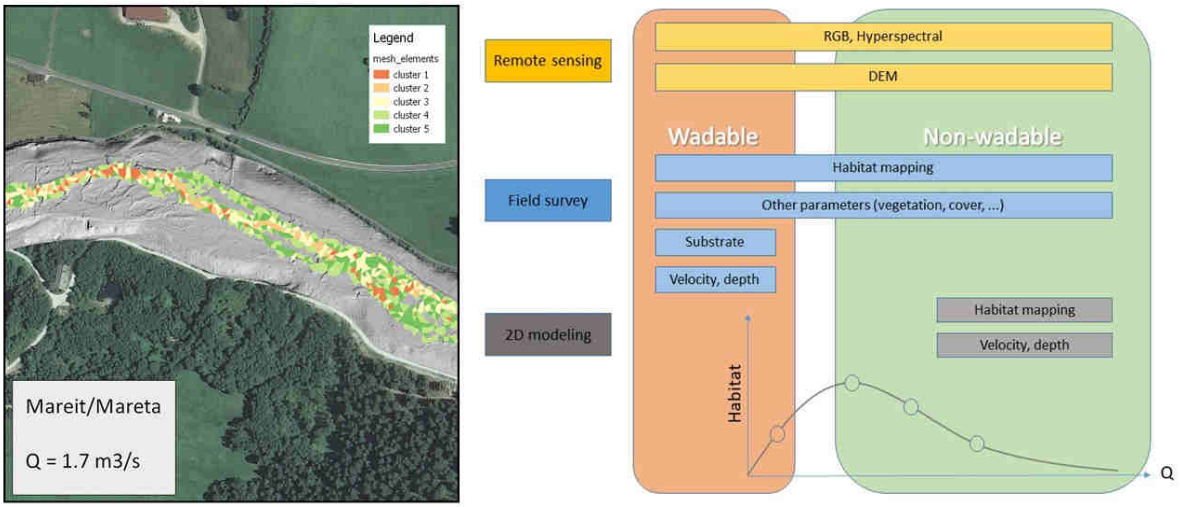

Fig 2: (A, left) An example of mesohabitats extracted from 2D hydraulic modelling through cluster analysis. (B, right) Methodological framework for the integration of remote sensing and hydro-morpho-dynamic modeling

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