ANALISI DELLA STRUTTURA DELLE COMUNITA' ITTICHE IN RELAZIONE A CAMBIAMENTI DI PORTATA DOVUTI A RILASCI DA PRESE IDROELETTRICHE PRESENTI NELL'ALTO CORSO DEL FIUME TAGLIAMENTO

ANALYSIS OF THE FISH COMMUNITY STRUCTURES IN THE BASIN OF THE HIGH TAGLIAMENTO RIVER IN RELATION TO AN INCREASE IN FLOW RATES FROM HYDROPOWER DIVERSION WEIRS

BERTOLI MARCO[1], GENTILI GAETANO[2], ROMANÒ ANDREA[2], DEANA ALBERTO[3], MARIN ANDREA[4], MORO GIUSEPPE ADRIANO[5] & PIZZUL ELISABETTA[1]*

1. *Dipartimento di Scienze della Vita - Università degli Studi di Trieste, Via Licio Giorgieri 10, 34127 Trieste (TS) * corresponding author: pizzul@units.it, 0405588830*
2. *GRAIA srl., Via Repubblica 1, 21020 Varano Borghi (VA)*
3. *Regione Friuli Venezia Giulia, Direzione centrale ambiente ed energia - Area tutela geologico-idrico-ambientale, Via Longarone 38, 33100 Udine (UD)*
4. *Studi & Misure Idrologiche e Idrobiologiche, Via San Marco 11, 33010 Reana del Roiale (UD)*
5. *Studio Consulenza e Biologia Ambientale, Via Pallanza 39/D,33100 Udine (UD),*

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Riassunto

La gestione artificiale dei flussi operata con sistemi di derivazione è fonte di modifiche al regime idrologico dei corsi d'acqua, a causa dell'alterazione nei naturali meccanismi di trasporto solido. Tali cambiamenti causano delle modifiche alle caratteristiche idrauliche e morfologiche dell'ambiente fluviale ed hanno come conseguenza l'allontanamento dalle condizioni di naturalità degli alvei, con forti ripercussioni sulla componente biotica dell'ecosistema lotico ed in particolare sulla comunità ittica. Tra gli impatti a cui l'ittiofauna è soggetta vi può essere l'impossibilità di effettuare migrazioni stagionali (a scopo riproduttivo o alimentare) a causa di ostacoli strutturali, la riduzione della biodiversità, l'alterazione della struttura della comunità, le variazioni nella quantità di biomassa, nonché l'abbassamento della produttività ittica e del successo riproduttivo.

Il presente lavoro si propone di esaminare la composizione delle comunità ittiche presenti in alcune stazioni nel bacino dell'alto Tagliamento (Friuli Venezia Giulia) poste a valle di alcuni sbarramenti nei torrenti Lumiei, nel torrente Degano e lungo il corso del Fiume Tagliamento stesso. Le analisi hanno avuto l'obiettivo di esaminare come le comunità ittiche hanno risposto ad un aumento del rilascio del minimo deflusso vitale.

Abstract

The water management in the streams, operated with diversion systems, cause changes in the natural flow rate regimes, due to modifications in the sediment transport dynamics, and consequently in the morphological and hydrological features of riverine environments. The loss of natural condition of riverbeds has a strong impact on the biotic communities living in lotic ecosystems, especially on fish fauna. In particular, species could be not able to perform seasonal migrations (for spawning or feeding) owing to structural obstacles, there could be an

alteration in community structures or changes in biomass values and, finally, biodiversity, productivity and reproductive success could decrease.
In the present study we analyzed the composition of fish communities in some sites placed in the basin of the High Tagliamento River (Friuli Venezia Giulia) downstream of some diversion weirs located in the Lumiei Stream, in the Degano Stream and in the Tagliamento River. Fish communities has been studied in order to check the response to an increase of the minimum flow rate.

Introduction

In lotic ecosystems, the construction of dams, weirs and water diversion systems for hydropower purposes causes modifications which lead to the disruption of river continuity (Boon 1988; Brittain & Saltveit 1989; Petts & Bickerton 1994; Maiolini *et al*. 2007). Among these changes, the variations of water flow regimes are one of the most widespread and most important disturbance (Almodòvar & Nicola 1999) which can origin strong effects on water temperature, water chemistry, sediment transport, streambed stability and biotic communities (Morgan *et al*. 1991; Moog 1993; Dudgeon 2000; de Mèrona *et al*. 2001; Lorenzoni *et al*. 2004; Maiolini *et al*. 2007; Franchi *et al*. 2014). Regarding fish fauna, disturbance could induce negative effects such as changes in structure and composition of the communities and/or cause a decrease in biological productivity (Forneris *et al*. 2007; Haxton & Findlay 2008).
In the last years conservation of the water resource has become increasingly important (Chiussi *et al*. 2009) and the release of the "Minimum Vital Flow" (MVF) has been indicated by the Lgs. D. 152/06 as a tool in order to achieve the objectives of quality provided by the Directive 2000/60/CE. In the Friuli Venezia Giulia Region, the Regional Law 28/2001 provides the execution of measurement and monitoring activities so as to determining the MVF values, in the context of the realization of the Regional Water Protection Plan. Consequently, from June 2007, an experimental plan of water release has been started in order to study the response of the river systems and to determine the MVF value such as to ensure an adequate level of protection in water bodies affected by the exercise of derivations.
With this premises, in the present study we evaluated the effect of the water releases on fish communities at four sites placed in the basin of the High Tagliamento River and included in the experimental plan mentioned above. The aim of our work was to investigate the presence of modifications in composition and densities of fish communities as consequence of an increase of the MVF between the years 2008 and 2014 (Table I).

Table I. Experimental water releases from some hydropower weirs placed in the basin of the High Tagliamento River planned between 2007 and 2015 (Source: Region Friuli Ven. Giulia).

Watercourse	Weir	Experimental discharge release (l s^{-1})			
		2007-2010	2013	2014	2015
Tagliamento River	Caprizi	430	570	570	570
Degano Stream	Ovaro	700	850	1500	850
Lumiei Stream	Plan del Sach	215	290	290	290

Materials and methods

Study area

The present work has been carried out in the basin of the High Tagliamento River (Figure 1). This is the first watercourse of the Friuli Venezia Giulia Region and one of the few ecosystems that still retains a fair natural condition (Lippert *et al*. 1995; Müller 1995; Ward *et al*. 1999). Regarding fish communities, the study area has a high value because it falls within the distribution zone of the marble trout (*Salmo marmoratus*), which is endemic in the Po-Venetian district and is included in Directive 92/43/CE Annex II. On the other hand, a

complex system of water diversion, built for hydropower purposes, finds place in the basin of the High Tagliamento River, involving approximately an area equal to 660 km^2, exploiting the waters of Tagliamento and of its tributaries, and capturing 40% of the total basin flow (Brusarosco *et al*. 2010). This system represent the main hydropower source for Friuli Venezia Giulia and it is a strategic hub for the italian energetic system (Friuli Venezia Giulia Region, Deliberation n° 1872/2012).

Sampling design

Four sites were monitored during the present study (Figure 1): four seasonal sampling campaigns have been performed on the fish communities in 2008, 2009 and 2010, during February, April, July and October; the following monitoring phase is still ongoing and the latest data reported in this study refer to July 2014. The sites were monitored also before the start of the experimental water releases and therefore we include in the present work the results of activities carried out during 2005 and 2006 (February and June) in order to make comparisons. Between 2005 and 2006 (before releases) and between 2007 and 2010 (after releases) flow rate measurements were performed by wading, using a flow meter with size adequate to water conditions and to morphological characteristics of the measured section, in compliance with ISO 748 protocol.

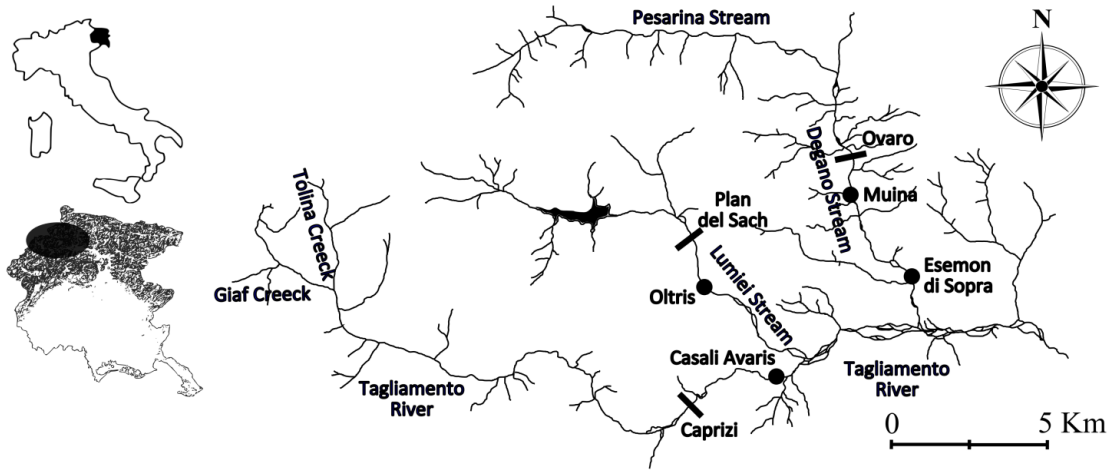

Figure 1. Study area: weirs are indicated with black bars and sampling sites are indicated with black dots (UTM sites coordinates: Casali Avaris 33T 332867,00 E 5139162,00 N; Oltris 33T 330841,28 E 5142848,38 N; Muina 33T 336605,09 E 5147377,55 N; Esemon di Sopra: 33T 339005,86 E 5143189,19 N).

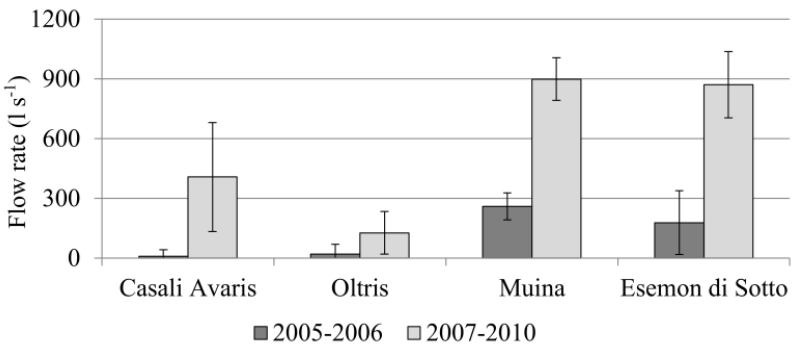

Figure 2. Average flow rates observed at the sampling sites before (2005-2006) and after (2007-2010) the beginning of the experimentation.

Fish were captured by wading watercourses with pulsed direct current backpack electrofishers (0,7-7 A; 150-380 V) which have been handled by personnel of the Safeguard Fish Authority of Friuli Venezia Giulia (ETP) (2008-2010) and by personnel of GRAIA Srl (2013-2014). Captures were performed using the removal method (Seber & Le Cren 1967; Seber 1973) within a section, delimited by nets, which length was proportional to the riverbed width (Forneris *et al*. 2005). The operations carried out until individual depletion. Fish have identified, counted and released in the same site, without consequences for vitality. Density values (ind m^{-2}) have been calculated for each species, in agreement with Seber & Le Cren (1967) and average annual density values, calculated for each site, were compared using the Kruskal-Wallis non-parametric test. Data obtained in 2013 and 2014 were reported, but not included in the statistical comparisons, as partial results referred only to one sample season.

Results and Discussion

The increase of water release from the diversion weirs has resulted in a significant enhancement of average flow rates in the monitored stations (Fig. 2), with effects on fish communities depending from the starting condition of the sites before the experimentation begins.

In the Casali Avaris site, bullhead *Cottus gobio*, *Salmo marmoratus* and brown trout *Salmo trutta* were observed. Between 2008 and 2010 density values ranged from 0,0013±0,0002 to 0,0023±0,0006 ind m^{-2} for the bullhead; from 0,0023±0,0016 to 0,042±0,0028 ind m^{-2} for the marble trout and from 0,0003±0,0000 to 0,0007±0,0006 ind m^{-2} for the brown trout (Figure 3a).

Even though application of the Kruskal-Wallis test did not allow to highlight significant differences among average annual density values for the observed species, an overall increase trend was found for each of them, which is likely confirmed by the data of 2014 (Figure 3a). In the Oltris site (Lumiei stream) *Salmo trutta* was the only species observed;

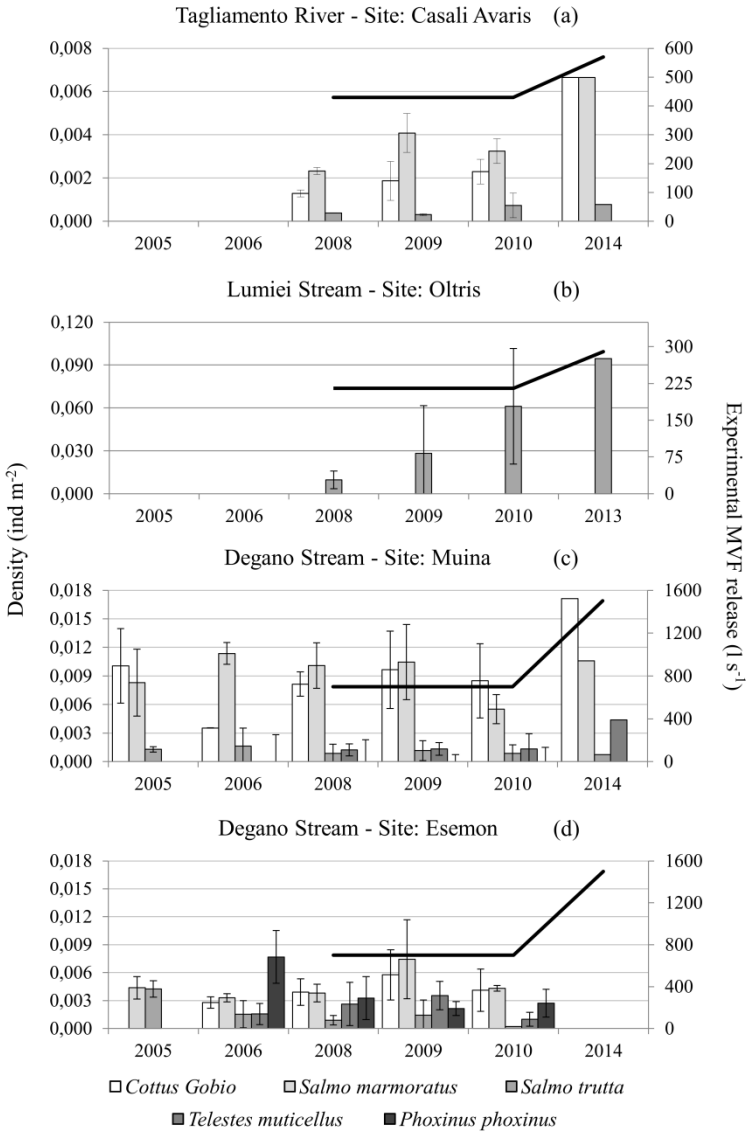

Figure 3.Densities of the observed species at the sampling sites (histogram). The experimental water releases planned from the hydropower weirs are represented by the black lines and referred to the secondary axis (l s-1).

between 2008 and 2010 brown trout showed densities which ranged from 0,0097±0,0062 to 0,0611±0,0404 ind m^{-2}. As in the Casali Avaris site, no significant differences were detected, but values tended clearly to increase through the years as confirmed by data collected in 2013 (0,0944 ind m^{-2}) (Figure 3b). The Casali Avaris and Oltris sites had shown a very critical condition before the beginning of the experimental releases, being practically dry all the year (Figure 2). With a constant water supply, the hydrological and morphological conditions such as to enable an increasingly more massive colonization have been recreated in these sites, where the progressive resett lement has been the main effect of the experimentation. In the Muina site (Degano Stream), before the beginning of releases (2005-2006), the density values ranged from 0,0035±0,0000 and 0,0100±0,0039 ind m^{-2} for *Cottus gobio*, 0,0083±0,0035 0,0114±0,0011 ind m^{-2} for *Salmo marmoratus*, 0,0013±0,0003 and 0,016±0,0019 ind m^{-2} for *Salmo trutta*. The same species were observed after the releases, showing values that did not differ significantly from those previously observed (Figure 3c), but in addition *Telestes muticellus* has been found. Between 2008 and 2010 this species showed densities which ranged from 0,0012±0,0006 and 0,0018±0,0016 ind m^{-2} (Figure 3c). Even this time, the application of the Kruskal-Wallis test did not allow to detect significant differences, but the increasing density values seem to indicate the tendency to a progressive colonization, which could be confirmed by data observed in 2014 (0,0044 ind m^{-2}). Even before the beginning of the water releases, the hydrological regime permitted the presence of a fish community at the Muina site (Figure 2; Figure 3c). However, at that time, flow rates did not allow the establishment of the river continuity between the reach represented by the Muina site and the reach represented by the Esemon di Sotto site, where *Telestes muticellus* was already present (Figure 3d). The enhancement of flow rates, consequent to the beginning of the experimentation (2008-2010; Figure 2), likely allowed this species to colonize the upstream habitats, following the restoration of the river continuity.

Conclusions

The management of a continuous minimum vital flow (MVF) can be used to rejuvenate habitat conditions for fish in regulated rivers (Ortlepp & Mürle 2003), and in complete dry reaches, introducing any kind of minimum flow may significantly increase habitat availability for aquatic organisms (Renöfält *et al*. 2009). A long term program can also improve the fish recruitment (Mannes *et al*. 2008). The results of this study suggest that ecological condition has been improved after the experimental releases. The increased MVF led to two main effects on the observed fish communities: (i) the recolonization of restored habitats previously compromised by water diversion and (ii) a shift to upstream for species, which were present downstream, following the restoration of the river continuity. Although density values have shown a clear increasing trend, the effects of the experimentation will be probably significant at the end of the ongoing monitoring, as the latest data seem to indicate. In fact, flow releases have to be repeated on regular basis to maintain their benefits (Renöfält *et al*. 2009).

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