The riverfly monitoring initiative: structured community data gathering informing statutory response

Daniele Di Fiore and **Ben Fitch** take us through the history of this monitoring initiative and how it makes possible, through public participation, the resolution of local environmental problems with local knowledge.

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There is increasing recognition that communities' approach to the environment has drastically changed within the last few decades. Protection of the environment has moved from a state where local communities "micromanaged" their resources by limiting overexploitation, to a more recent condition where environmental issues have become so complex that only trained specialists can analyse and confront problems. Over the last few decades, extreme weather events due to climate change, overexploitation of resources, and poor understanding of long-term impacts, have contributed exacerbating and making local environmental problems unmanageable. Consequently, awareness of the most pressing environmental issues has amplified dramatically, causing a stronger sense of stewardship towards local habitats, with local communities demanding a more active role in the protection of their environment.

The Anglers' Riverfly Monitoring Initiative (ARMI), coordinated nationally by the Riverfly Partnership, is an exemplary citizen science initiative, which enables people to reconnect with, and protect, their local freshwater environment, whilst contributing towards scientific research. The Riverfly Partnership is a network of organisations including anglers, conservationists, entomologists, scientists, watercourse managers, relevant authorities and other groups interested in protecting water quality and riverine habitats. ARMI, launched in 2004, mobilises regular "eyes and ears" on hundreds of river sites throughout the UK and, by recording macroinvertebrates, provides a means for trained citizen scientists to make a direct contribution to the protection of local rivers, whilst enhancing their own understanding of the river ecosystem. ARMI volunteers also contribute to the improvement of their local environment by helping to deter illegal fishing and pollution, and by recording information related to positive conservation management such as, invasive non-native species, livestock poaching, together with natural and unnatural impoundments. ARMI volunteers are able to monitor more river sites at a greater frequency than current resources allow United Kingdom (UK) statutory bodies to monitor.

HISTORY OF THE RIVERFLY PARTNERSHIP AND ARMI

The history of the Riverfly Partnership dates back to the 1980s when Dr Cyril Bennett pioneered angler flylife monitoring and entomological courses for anglers, and which were managed by Steve Brooks and Peter Barnard at the Natural History Museum, London. During the following decade, Riverfly identification courses were delivered by Warrant Gilchrist, Dr Bennett and their colleagues at the John Spedan Lewis Trust for the Advancement of the Natural Sciences (JSLTANS) in Hampshire. In his 1995 work entitled "A guide to water quality", Stuart Crofts encouraged non-specialist monitoring of the chemical parameters of rivers, and then in 1999, invertebrate monitoring conducted by Dr Bennett, highlighted serious pollution incidents in the River Wey, Hampshire.

In 2001, the Environment Agency (EA) and Wiltshire Fishery Association published "Report on the millennium chalk streams fly trend study"[1], which highlighted the decline of flylife across chalk streams in Southern England. In the same year, the Journal of the Grayling Society published "Riffle sampling'" by Stuart Crofts, which outlined the need for non-specialist biological water quality monitoring in rivers. Shortly after, a partnership between the Natural History Museum (NHM) and Natural England (NE – then English Nature), established to promote recording and surveying of invertebrates. The Partnership's leaders identified riverflies as a focus. The following year, riverfly identification and monitoring workshops were organised in Hampshire as part of a collaboration between the NHM/EN Partnership, JSLTANS and the Ephemeroptera and Trichoptera Recording Schemes. The NHM/EN Partnership's riverfly work became subject of the "Amateurs as experts" project, which was organised by the Institute for Environment, Philosophy and Public Policy at Lancaster University. Riverfly workshops continued around the country in subsequent years.

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The Riverfly Interest Group, with key partners including the EA and Salmon and Trout Conservation UK (S&TC – formerly Salmon and Trout Association), was established by "Buglife", the NHM/EN Partnership and others. The Riverfly Interest Group hosted the first national riverfly conference entitled "Riverflies: a beacon of environmental quality" during November 2004, thereby launching the Riverfly Recording Schemes and establishing the Riverfly Partnership at the same time.

In turn, and with EA collaboration, the Anglers' Monitoring Initiative (AMI) pilot began in 2005. AMI launched nationally in 2007 and has been referred to as the ARMI since 2012.

CASE STUDY

CITIZEN SCIENCE MONITORING

In relation to water management, many citizen science programmes have employed biotic indices originally developed by scientists and statutory bodies to investigate water quality. In 2000, the Water Framework Directive (WFD)[2] was published, setting broad frameworks for biological monitoring. In subsequent years, standards were agreed and existing schemes across Europe became generally harmonised. Surprisingly, there has been a strong similarity between different European Union (EU) countries, as the majority of the indices fall into the category of the Biotic Index[3]. The methods involve sampling taxa that are known to have differing degrees of tolerance/sensibility to pollution and/or water quality parameters, therefore, the presence and relative abundance of certain taxa indicates distinct water characteristics and pollution levels.

In the UK, the most used indices are the Biological Monitoring Working Group(BMWP) and the Average Scores per Taxon; both are often used alongside the River Invertebrate Prediction and Classification System and the River Invertebrate Classification Tool to produce a comparison of observed versus expected scores based on river characteristics[4]. The Whalley, Hawkes, Paisley and Trigg (WHPT) metric is a new species level identification and abundance weighted method, which was developed recently in response to the requirements of the WFD. This metric enables the assessment of invertebrates in rivers with relation to general degradation, including organic pollution. These indices are used only by trained professionals to sample for macroinvertebrate taxa, and to exploit their presence as a means to assess waterbody health. Results from these surveys are taken into account when drafting a WFD River Basin Management Plan.

Biotic indices have been elaborated *ad hoc* and amendments have been regularly investigated to achieve greater accuracy[5]. The growing number of initiatives that involve citizen science has resulted in a multitude of data in the databases, comprising of complementary and non-complementary datasets, which subsequently become available for scientific analysis. Positive results have been achieved in many research projects involving volunteers[6]. As well as providing valuable data with extended spatial and temporal resolution, citizen science results have provided an improved level of knowledge of environmental issues and a stronger sense of "making a difference".

DATA QUALITY AND METHOD VALIDATION

A common criticism of citizen science is that the data generated is potentially of lower quality than professional sampling for reasons including diminished methodological standards, limited technical capacity, and lower-quality equipment[7]. Furthermore, some authors[8] argue that different groups may have different goals, thus pursuing methods not adequately matched to the purpose of research. Concurrently, concerns have been raised regarding the ability of different indices to detect the correct health status of the environmental medium being assessed. The main issue of concern has been the creation and definition of reference conditions, which could result in different biotic indices giving dissimilar results and inconsistencies within the same environment.

The ARMI monitoring technique, developed in collaboration with the EA and utilised by the Riverfly Partnership, avoids the implication of the aforementioned problems by simplifying the BMWP methodology, which has proven scientific validity and extensive use in the UK. In detail, the ARMI method enables trained volunteers to carry out a three minute kick sample every month, using the same sampling technique and specification equipment used by EA ecologists. Presence and abundance of the larval stage of eight invertebrate groups (seven of which are riverflies) is recorded so that severe changes in water quality can be identified. The eight "target groups" of invertebrates used in ARMI are:

- Cased caddis *Trichoptera*;
- Caseless caddis *Trichoptera*;
- Mayfly *Ephemeroptera*;
- Blue-winged olive *Ephemerellidae*;
- Flat-bodied *Heptageniidae*;
- Olives *Baetidae*;
- Stoneflies *Plecoptera*;
- Freshwater shrimp *Gammarus spp.*

▲ **Figure 1. Cased caddis fly larvae create protective shells bound together with strands of silk. Both cased and caseless caddis flies (Trichoptera) are "target groups" studied under the ARMI methodology (© Alle | Dreamstime).**

▲ **Figure 2. In the ARMI methodology, trained volunteers carry out a three minute kick sample every month to record presence and abundance of the larval stage of eight invertebrate groups (© Mark Everard).**

Each target group, included in the ARMI methodology, was selected based upon sensitivity to (largely organic) pollution, distribution and status in rivers across the country, and presence throughout the year. Key identification and morphological characteristics ensure that volunteers can be trained to identify, sort and record invertebrates according to each target group, thus producing an ARMI score, which is compared to the site-specific EA "trigger level" (expected population abundances). If invertebrate numbers drop below the trigger level, the EA is notified so that more detailed investigations and appropriate response action can take place. The EA provides the relevant ARMI monitor with feedback concerning any actions taken which validates the volunteer's efforts and maintains ongoing motivation. An online data repository enables registered users to track survey results over time, from every registered UK ARMI site.

INFORMING STATUTORY RESPONSE AND CONNECTING PEOPLE WITH RIVERS

Citizen science is gaining favourable attention as an approach that "*Can inform natural resource management and has some promise for solving the problems faced by adaptive management*"[9]. Adaptive management is a methodology that focuses on identifying critical uncertainties with the aim of reducing risks over time via experiments and system monitoring. Buytaert et al. (2016)[10] recognised that involvement of citizens with water resources, is increasingly mutating the relationships between risk, monitoring and decision making processes. Specifically, the participation of the general public in monitoring initiatives and science-related projects results in the generation of new scientific knowledge. Citizen science projects can comprise of several objectives such as:

- Scientific;
- Educational;
- Economic;
- Social.

Building upon these objectives, ARMI facilitates the reconnection of people with their local environment, whilst advocating greater public dialogue and an active participation of local communities in the protection of rivers.

ARMI, as citizen science in general, makes possible the development of monitoring on large spatial and temporal scales, collecting a large volume of data and creating a form of public participation that allows individuals to bring local knowledge to solve local problems. The initiative encourages the sourcing of information that is hard to attain through traditional methods. Furthermore, the meeting between researchers and citizens represents an opportunity to enhance the collective awareness about scientific research: why it is performed, whom it benefits, and its weaknesses. This potentially leads to a change of people's behaviour, reducing those activities that have a negative impact on the environment. It also fulfils the demands of local communities in that they have a say in environmental

issues, makes them directly and actively aware of the development of local policies, and of the environmental status of their local area. All this is accomplished with lower financial costs than monitoring developed by professional operators using other techniques.

There are several documented cases of ARMI success[11], including identification of serious pollution incidents and prosecution of polluters such as, the River Kennet in 2013[12]. ARMI, through collaboration, provides valuable information about water quality, which helps statutory bodies to assess and control the health of waterbodies, whilst directly benefitting local volunteers who seek to protect their watercourses.

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