Early careers on ecohydraulics: challenges, opportunities and future directions

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EARLY CAREERS ON ECOHYDRAULICS: CHALLENGES, OPPORTUNITIES AND FUTURE DIRECTIONS

Abstract

Early career researchers (ECRs) play a critical role in our increasingly knowledge-based society, yet they are the most vulnerable group in the scientific community. As a relatively young, interdisciplinary science, ecohydraulics is particularly reliant on ECRs for future progress. In 2014 the Early Careers on Ecohydraulics Network (ECoENet) was created in order to help the development of young researchers working in this field. In this paper we synthesise the outcomes of a workshop for ECRs organised by ECoENet in February 2016. We aim to show how the potential of ECRs can be maximised in order to drive progress in ecohydraulics. According to the most recent entrants to the field, major challenges in ecohydraulics lie in becoming more integrated as a discipline, developing a common vocabulary and a collective vision, engaging effectively with policy makers, and encouraging public participation. To address these challenges in the future, ECRs need to develop their careers on an international scale in a way that crosses traditional disciplinary boundaries, including the social sciences, and allows them time to work at fundamental levels rather than focusing solely on individual applications. Herein, we propose a strategy to facilitate this by providing: a platform for disseminating research; an international support network; and a set of international services for enhancing ECR training and experience.

Keywords: Early career researchers; interdisciplinary science; ecohydraulics; society; ecology; hydraulics

EARLY CAREERS ON ECOHYDRAULICS: CHALLENGES, OPPORTUNITIES AND FUTURE DIRECTIONS

1. Background

Environmental systems are characterised by a diverse range of multi-scale interconnections that are often defined by dynamic relationships (Peterson 2000). Understanding and working with these systems holistically is recognised as the key to managing contemporary environmental issues (Barnard & Elliot 2015; Nestler et al. 2016). Diverse skills and tools are therefore required to solve such complex environmental problems. Whilst environmental science is becoming increasingly interdisciplinary, with individual sub-disciplines drawing more from closely related fields, it still only moderately interacts with more distant fields such as social sciences and economics (Porter & Rafols 2009). At the same time, traditional disciplines are becoming increasingly specialised, creating barriers for interdisciplinary research (Nestler et al. in review).

Against this background, ecohydraulics has gained recognition as a truly interdisciplinary science (Rice et al. 2010; Maddock et al. 2013a), with active research groups such as the International Centre for Ecohydraulics Research (ICER; http://www.icer.soton.ac.uk) and the Center for Ecohydraulics Research (CER; http://www.uidaho.edu/engr/research/cer). It began as a means to bridge ecology and hydraulics (Mader & Kraml 2014), but today ecohydraulics spans a range of other disciplines, such as biology, fluvial geomorphology, hydrology, river engineering and water resources management (Maddock et al. 2013b). Ecohydraulics plays an important role in increasing our knowledge of aquatic ecosystems and understanding how humans are impacting them (Mader & Kraml 2014).

The cross-disciplinary nature of ecohydraulics makes it highly suited to the development of a global network of Early Career Researchers (ECRs) capable of tackling contemporary and emerging environmental issues. ECRs play a particularly significant role in shaping the future of our increasingly global, knowledge-based society (Pain 2014), yet are the most vulnerable group within the scientific community (Laudel & Gläser, 2008). Short-term postdoctoral contracts, a large disparity in the number of PhDs awarded and the availability of research positions, limited funding targeted towards supporting ECRs, and the challenge of competing against established researchers (Bazeley, 2003; Cyranoski et al., 2011) can result in many turning away from pursuing research careers. Mentorship and effective support networks are recognised as important for mitigating this (e.g. White, 2004; Kahn & Greenblatt, 2009). As such, early career networks are high on the agenda of many funding and science bodies worldwide, yet most early career initiatives are split geographically and/or by discipline (Rauser et al., 2015).

The Early Careers on Ecohydraulics Network (ECoENet) was created in 2014 following discussions among ECRs working in ecohydraulics that highlighted the necessity and value of building a professional network at the start of a research career. Following the example of the Young Earth System Scientists (YESS) community (Rauser et al. 2015), ECoENet has been established through a bottom-up process to facilitate effective interdisciplinary networking by allowing all members to have an equal voice. The network currently has 89 members across 23 countries, and an active online presence (http://www.ecoenet.link).

2. Engaging early career researchers within ecohydraulics

In February 2016, ECoENet organised its first workshop attached to the 11th International Symposium on Ecohydraulics, Melbourne. The one-day workshop aimed to provide an opportunity for ECRs to network, share ideas and improve understanding of how they can contribute towards developing ecohydraulics as a discipline. The workshop was attended by 25 participants from 10 countries. Africa and South America were the only continents not represented.

In order to better understand the views of ECRs as researchers in the field of ecohydraulics, we used a method of inquiry known as 'participatory action research' (PAR). PAR works through iterative cycles of participation, action and reflection. The method has been shown to have good properties (open, equitable, reflective, action-orientated) to help researchers contribute to meaningful change in situations characterised by uncertainty (Chevalier & Buckles, 2013). We used PAR to address the following questions: (i) what are the major challenges in ecohydraulics? (ii) what are the barriers and opportunities for ECRs in meeting these challenges? and (iii) how can a research network help? Sections 3-5 of this paper relate to each of these questions in turn.

By synthesising the responses of participants, this paper seeks to represent the views of ECRs within ecohydraulics. In doing so, it shows how the ecohydraulics community can optimise the potential contribution of ECRs to the discipline and defines the role of ECoENet in facilitating this.

3. Major challenges in ecohydraulics

ECRs can provide a potentially rich source of information on disciplinary challenges due to their recent training and progressive mindset (Gilvin et al. 2012). Maddock et al. (2013c) identify four future challenges for ecohydraulics: (i) measuring and

modelling turbulent flow properties and their influence on ecological communities (i.e. biophysical relationships); (ii) interdisciplinary integration and cooperation; (iii) transferability across temporal and spatial scales; and (iv) ecohydraulics and management (the application of research to management). In many cases the challenges identified by ECRs, summarised in Table 1, were related to these broad categories.

Echoing several previous commentaries in the last decade (e.g. Newman et al. 2006; Hannah et al. 2007), ECRs acknowledged the need to integrate the disparate vocabularies, concepts and approaches of the ecological and hydraulic sciences. They also thought that the involvement of social scientists and economists should be one of the major priorities for ecohydraulics. Compared to Maddock et al. (2013c), ECRs placed more emphasis on issues of direct relevance to society, including ecosystem services. They were much more cognizant of the need to engage with public and political spheres through dissemination in the mainstream media, informing public debates on environmental policy, promoting citizen science and increasing the influence of ecohydraulics on policy making.

[Table 1 near here]

4. Barriers and opportunities for early career researchers

ECRs reflected on both the barriers and opportunities facing them in their attempts to meet the major challenges outlined above. The participants identified factors relating to education and knowledge production, professional development and welfare. We summarise each of these themes below.

4.1 Education and knowledge production

A recurring theme of the workshop related to the lack of interdisciplinary academic departments, undergraduate degrees or masters-level courses specifically devoted to ecohydraulics. Specialised courses are typically taught within engineering or ecology departments. ECRs felt that this limits their potential to contribute towards progress in the field by creating institutional barriers to truly interdisciplinary training. Within the hierarchical structure of ecohydraulics (Nestler et al. in review), PhD students and postdoctoral researchers are typically engaged in applications of existing knowledge and technologies. However, ECRs unanimously wanted opportunities to be involved in fundamental research at 'discipline' and 'paradigm' levels (*sensu* Nestler et al. in review), rather than focusing solely on individual applications as is often the case in PhD and postdoctoral projects, in order to progress ecohydraulics as an integrated science.

4.2 Professional development

ECRs felt they had limited understanding of potential career goals and pathways within ecohydraulics. The majority lacked a senior mentor they could call upon for advice. Overwhelmingly, participants reported the desire to contribute to positive change within society as part of their career aspirations. A number of opportunities to achieve this were discussed and centred upon increased involvement of industry partners and policy-makers in PhD supervision, chances to take part in non-academic placements, and the pursuit of effective public engagement and participation in ecohydraulics. This is an area where the ecohydraulics discipline is well positioned to deliver due to its applied nature. However, postgraduate students should be given more opportunities to learn skills for effective communication with stakeholders and,

where appropriate, training for futures in ecohydraulics-related careers outside academia (e.g. Blickley et al., 2013).

4.3 Welfare

ECRs were concerned about maintaining an acceptable work-life balance in a highly competitive academic climate with great pressure to publish at an early stage. This is compounded by uncertainty due to short-term postdoctoral contracts and the need to be internationally mobile in order to seek secure positions. Most participants agreed that a gender imbalance prevails within ecohydraulics, as in many scientific disciplines (Leslie et al. 2015), particularly with regard to female representation in the most senior academic community. The tension between professional development and family life was recognised as an issue that may disproportionately affect female ECRs.

5. Future directions: Harnessing the potential of early career researchers in ecohydraulics

Despite the suggestion that ecohydraulics is 'an integrated approach' (Maddock et al. 2013a), the most recent entrants to the discipline still feel that a great deal of effort is required to fully integrate the whole range of requisite concepts and approaches from the natural and social sciences. The development of a common vocabulary, the articulation of a collective vision and the production of fundamental ecohydraulic concepts are critical steps to achieving this. Ecohydraulics has rarely produced its own paradigms (but see Nestler et al. 2016), instead borrowing from related disciplines. ECRs can make a powerful contribution to overcoming these challenges if

they are offered opportunities to divert time and resources to work at basic levels in the hierarchy of ecohydraulic knowledge (Nestler et al. in review).

ECRs are acutely aware of the need for ecohydraulics to interact more closely with the social sciences. This is not to suggest that the scientific community has been benign in this regard, but there is much greater scope for encouraging the participation of public and political stakeholders in line with global initiatives to promote transdisciplinarity, such as Future Earth (2013). For example, ecohydraulics has been extremely slow to harness the power of citizen science, in contrast to other ecological and hydrological sciences (Dickinson et al. 2012; Buytaert et al. 2014). No chapters in Maddock *et al*. (2013a) deal with public participation, citizen science or ecosystem services, issues that ECRs feel strongly about. The early career community is highly motivated to pursue these approaches in order to drive progress. ECoENet aims to facilitate a move towards more wide-reaching communication and participation as a priority (Figure 1).

[Figure 1 near here]

Ecohydraulics is an international community whose collective progress is dependent on cross-border collaboration. Although efforts have been made in this direction there is still a particular need to engage and exchange knowledge with African and Latin American researchers, who are underrepresented in ECoENet and the wider ecohydraulics community. ECoENet has members from all continents and is actively working to maximise the participation of Latin American and African ECRs, including through efforts to secure funding for their attendance at future ecohydraulics symposia. Furthermore, in an attempt to raise the profile of Latin

American ECRs, ECoENet is currently publishing a blog series by two Chilean members on its website.

Establishing research centres such as ICER is an important step towards institutionalising the discipline. However, there is a need to go further in order to realise the full potential of future ecohydraulics specialists, regardless of nationality or location. ECoENet proposes a location-independent 'virtual lab' as a platform for ecohydraulics-specific training and research opportunities. The platform would seek to both strengthen the identity and integration of the discipline and to mitigate some of the key barriers facing ECRs. This would include organised exchanges with policy and industry stakeholders in order to increase interdisciplinary collaborations (Rijnsoever & Hessels, 2011) and address the need for holistic approaches to contemporary environmental issues (Barnard & Elliot 2015; Nestler et al. 2016), research 'sand-pits' (Giles 2004) focusing on paradigm-level research, and a mentor scheme to support members in their pursuit of excellent research, including the production of fundamental concepts in ecohydraulics. The network aims to develop this proposal in the longer term through a series of steps shown in Figure 1. They include the following:

(i) Outreach

ECoENet is being promoted through existing postgraduate groups (e.g. NoWPAS Salmonid Research Network, Canadian Rivers Institute), conferences (e.g. Symposium of the International Society for River Science, Canadian Water Resources Association Conference) and the wider networks of its members.

(ii) Online presence

ECoENet is active on social media and already has an online presence through its website. The network's future strategy rests on two main pillars: internal communication among the members, which includes scientific discussions and sharing of professional experiences; and external communication with the general public, policy makers and other research disciplines.

(iii) Key participation at ISE

The network aims to continue providing an enabling environment through ECR workshops at future ecohydraulics symposia. It is currently planning the ISE2018 workshop in collaboration with the local organising committee in Japan.

(iv) Mentor scheme

The scheme will connect ECRs to senior scientists, environmental managers and policy makers. ECoENet is currently establishing a mentor-member list and an online platform to host the scheme.

(v) Training and education

The training and education programme will include: targeted webinars; a working paper series; online interviews with key scientists, environmental managers and policy makers; and research 'sand-pits', allowing ECRs time to focus on fundamental ideas.

(vi) Research and policy exchanges

Exchanges will provide members with opportunities to gain experience with key actors in different locations and disciplines. Specific programs could also include PhD placements in industry.

(vii) Promoting citizen science

As a long-term goal, ECoENet aims to encourage citizen science as a tool for research and public engagement in ecohydraulics (see Dickinson et al., 2012 for a review on

citizen science in ecology). Special sessions at future ISE symposia will develop this goal further.

Whilst issues raised in the workshop regarding ECR welfare are not specific to ecohydraulics, ECoENet can help to address them by providing opportunities for ECRs to build wider professional networks and facilitating better ecohydraulics-specific training. The network will place a special emphasis on the role of women in ecohydraulics, including through the availability of female mentors and website features (blogs, interviews) focusing on female members of the ecohydraulics community. ECoENet will also connect with other ECR networks in order to lobby wider academia for better consideration of ECR welfare, particularly with regards to the widespread problem of short-term postdoctoral contracts.

A useful framework for organising international ECR initiatives is Global Community Innovation Platforms (GCIPs). These open online infrastructures seek to improve innovation and knowledge exchange. GCIPs are characterised by several key features: (i) they are global in scope; (ii) they connect important local communities; (iii) they focus on methodological innovation and challenging paradigms; and (iv) they provide a common platform for sharing resources and ideas (Jørgensen et al. 2015). In addition, we argue that the strongly interdisciplinary and very applied nature of ecohydraulics requires further explicit features: (v) connect important natural and social sciences networks; and (vi) engage political actors and the general public. Table 2 relates these key features to the future directions identified in Figure 1.

6. Concluding remarks

ECRs are critical to the future of ecohydraulics, a discipline with important contributions to make within the wider scientific community and society as a whole. The main challenges in ecohydraulics lie in becoming more integrated as a discipline, including developing an integrated set of tools and fundamental concepts, engaging the public and influencing policy (Nestler et al. in review). In order to drive progress, ECRs need to develop their careers on a truly international scale in a way that crosses traditional disciplinary boundaries, including the social sciences, and allows them time to work at fundamental levels rather than focusing solely on individual applications. These opportunities should be independent of gender, status and nationality. ECoENet can help to facilitate this by providing a platform for disseminating research and an international network that enhances ECR training, experience and potential.

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Table 1. Major challenges in ecohydraulics identified by early career workshop participants. *Categories from Maddock et al. (2013c).

Biophysical relationships* • Establishing new concepts and paradigms in ecohydraulics • Defining the limits of the current knowledge • Developing new tools and methods (e.g. next generation habitat models) • Harnessing new technological advances (e.g. biotelemetry, velocimetry) • Going beyond single species
Interdisciplinary integration and cooperation* • Defining a common vocabulary • Firmly establishing the Journal of Ecohydraulics as a truly interdisciplinary journal • Agreeing a collective vision for the future of ecohydraulics • Overcoming disciplinary separatism • Optimising the integration of tools from different disciplines • Including social scientists and economists
Transferability across temporal and spatial scales* • Unifying concepts of scale in hydraulic and ecological sciences
Ecohydraulics and management* • Integrating ecosystem services • Supporting decision makers with timely information • Linking theory to practice (and practice to theory) • More monitoring of restoration projects (e.g. environmental flows)

Public and political engagement

- Communicating research to the public via mainstream media
- Informing public debates
- Encouraging public participation in research (i.e. citizen science)
- Interacting with stakeholders early in the research process

Table 2. Future directions for ECoENet and how they are related to the key features of Global Community Innovation Platforms.

Steps towards the Future direction of ECoENet	**1 Global scope**	**2 Local communities**	**3 Innovative**	**4 Common platform**	**5 Connect disciplines**	**6 Policies and people**
Outreach	•	•			•	
Online presence	•			•		
Key participation at ISE	•			•	•	
Mentor scheme		•	•			
Training and education		•	•			
Research and policy exchanges		•	•		•	•
Citizen science			•			•

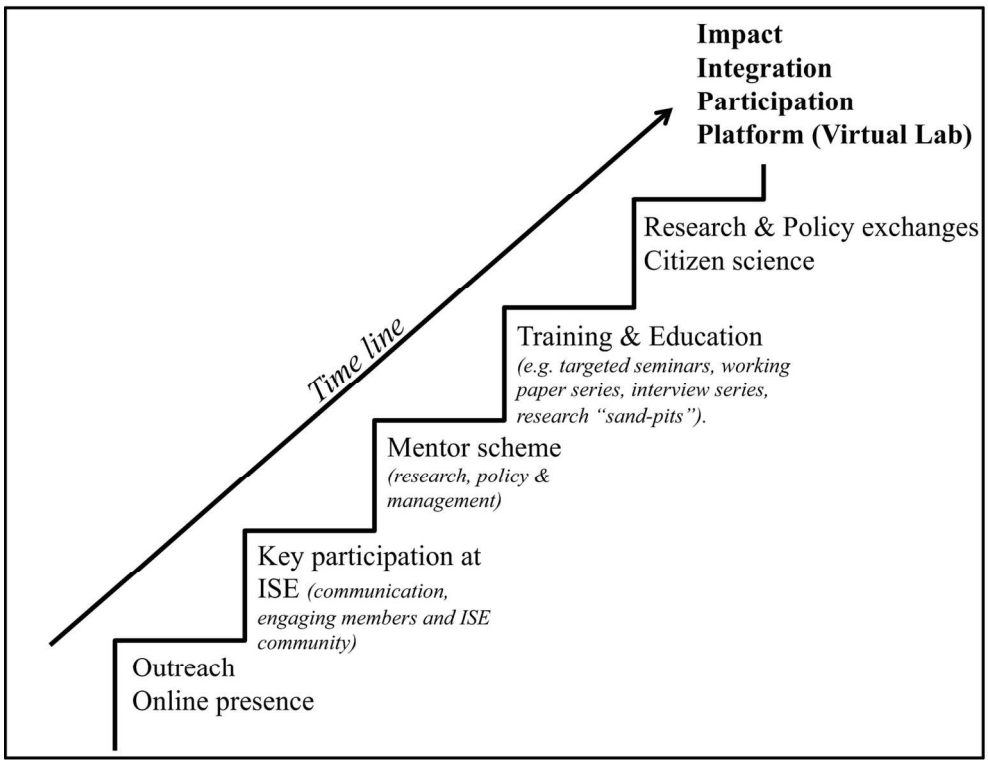

Figure 1. Future directions for ECoENet ordered by a timeline of implementation from short term actions to long term.

[Figure 1 near here]

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