Supplement

Invitation to participate in grand challenges paper

The past 50 years of research and application of aquatic biomonitoring has generated foundational research initiating global implementation of monitoring and assessment programs. Yet, despite the resounding success and impact of aquatic biomonitoring on managing freshwater ecosystem health, aquatic systems have never been more threatened as we continue to see degradation of these ecosystems. This degradation is associated with the expanding and intensifying influence of human activities on landscapes and the cumulative impacts resulting from the interaction of multiple stressors. Moreover, these threats occur increasingly in regions where socio-economic barriers limit the capacity for and accessibility to current aquatic biomonitoring approaches. Thus, there is urgent need for a modified biomonitoring paradigm that explicitly includes the value of aquatic ecosystems to society, effectively informs decision-makers of the consequences of management action, and that is globally accessible.

Fortunately, these challenges are arising during an unprecedented development of novel assessment technologies and approaches that could transform aquatic biomonitoring. Clearly, there is an opportunity to rethink the theoretical and operational underpinnings of the field of aquatic biomonitoring. Thus, it is timely and imperative to ask, **"What are the grand challenges that, when addressed, will advance aquatic biomonitoring towards a more effective and inclusive aquatic biomonitoring future?"**.

As a global group of aquatic biomonitoring researchers, we invite your participation in this endeavour in two respects.

First, we ask you as expert biomonitoring researchers, practitioners or end users to identify your most salient and immediate challenges (up to 5), that when addressed, will position aquatic biomonitoring to meet the challenges and opportunities that will arise in the coming decades of the Anthropocene.

Second, we offer co-authorship to those who solicit and submit challenges from at least five of their aquatic biomonitoring colleagues. We encourage you to select these colleagues from all sectors of aquatic biomonitoring in each of your respective regions.

The challenges we receive will be compiled, organized and communicated in an open-access journal article.

Below are two examples of challenge statements to give you an idea of the scope and context we are envisioning being incorporated into the statements.

Example Challenge 1. Develop protocols that enable informative continental to global scale assessments of aquatic ecosystems

Example Challenge 2. Establish the impacts of human activities through time under the context of a changing global climate

To complete our survey, please send your challenges, as well as job title, employment sector, and country of employment to biomonitoring.challenges@gmail.com by February 23, 2024.

Thank you, in advance, for contributing your time and ideas to this project. We will keep you informed on the progress of this initiative through regular updates.

Kindly,

Drs. Adam Yates, Robert Brua, and Joseph Culp

Table S1. Annotated list of the key themes in the 1034 challenges identified by ChatGPT 4.0. Each theme highlights a critical area of focus for advancing the field of aquatic biomonitoring and underscores the multifaceted approach required to protect and conserve aquatic biodiversity effectively.

Themes identified by ChatGPT 4.0
1. **Technological Innovations**: Adoption and integration of cutting-edge technologies like environmental DNA (eDNA) and artificial intelligence (AI) for more efficient species identification and ecosystem monitoring.
2. **Collaborative Efforts**: The importance of collaboration among government bodies, academic institutions, non-governmental organizations (NGOs), and local communities for effective data sharing and monitoring practices.
3. **Climate Change Resilience**: Developing strategies to adapt biomonitoring methods to the challenges posed by climate change, including altered species distributions and changing ecosystem dynamics.
4. **Policy and Financial Support**: Advocacy for stronger policy frameworks and increased funding to support biomonitoring activities, emphasizing the role of biomonitoring in informed policy-making and conservation planning.
5. **Education and Capacity Building**: Enhancing the skills and knowledge of both professionals and citizen scientists in biomonitoring techniques, stressing the need for educational programs and training.
6. **Addressing New Threats**: Identifying and managing emerging threats to aquatic ecosystems, such as invasive species and pollution, through improved monitoring and intervention strategies.
7. **Standardization of Methods**: The necessity for standardized and harmonized monitoring protocols to ensure data comparability across different regions and time periods, facilitating global assessments of aquatic biodiversity and ecosystem health.

Table S2. Definitions of sector and role categories assigned to challenge contributors.

Employment Classification	Category	Definition
Sector	Academia	University or other institution of higher learning
	Government	Governing body of a nation, state or community
	Not-for-Profit	Non-government entity operated for a collective or social benefit
	Private Sector	Non-government entity operated as a business to generate profit
Role	Researcher	Conducts research on aspects of freshwater biomonitoring
	Practitioner	Engages in the practice of freshwater biomonitoring (e.g., data collection or data management)
	Manager	Administers freshwater biomonitoring projects and/or programmes