








## ESSAY

# Wikipedia can help resolve information inequality in the aquatic sciences

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### Scientific Significance Statement

Generation of and access to scientific information have traditionally been limited to those with privilege or power. The internet, and the development of Wikipedia, has revolutionized the way information is shared by allowing everyone connected to the internet to generate and access content. However, the scientific community has not taken full advantage of this information dissemination paradigm. This is particularly true in the aquatic sciences, as is evidenced by the scarcity and low quality of aquatic information on Wikipedia. We argue that societies, institutions, and scientists should prioritize and incentivize contributing to Wikipedia in parallel to traditional scientific outlets to increase both equity and efficiency in transferring aquatic scientific information among our community and to the public.

*Those with access to these resources — students, librarians, scientists — you have been given a privilege. You get to feed at this banquet of knowledge while the rest of the world is locked out. But you need not — indeed, morally, you cannot — keep this privilege for yourselves. You have a duty to share it with the world.*

Aaron Swartz (2008)

### Scientific dissemination in the internet age

Dissemination of and access to scientific information has long been controlled by professional broadcasters, namely publishers, journals, and popular radio or television shows.

Professional broadcasters disseminate scientific information via print, audio, and video to recipients, including scientists, politicians, and the public (Nelkin 1995; Logan 2001). Through this system, those who are heard are those *who can speak*, and those who can speak have primarily been entities with substantial resources, wealth, and influence. We contend that this method of scientific information transfer has primarily served those with privilege or power.

The advent of the internet fundamentally changed the structure of how information is transferred, shifting control of dissemination away from professional broadcasters. Anyone with access to the internet can both broadcast and receive

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information. Thus, the internet has the potential to create a more efficient, democratic, and equitable transfer of knowledge. When everyone can speak, the broad dissemination of scientific information becomes a question of *who gets heard*. Control of *who gets heard* has shifted toward those who help organize and compile information including search engines like Google that use algorithms to sift through available information and direct users to what they deem most relevant. Democratized broadcasting platforms, including Wikipedia (a free community-generated encyclopedia) and Wikidata (a free community-generated structured database), are highly prioritized by these search algorithms (McMahon et al. 2017; Vincent & Hecht, 2020). Both Wikipedia and Wikidata have great potential to share scientific knowledge more equitably than prior broadcasters and improve public understanding of scientific topics (Brossard 2013). Unfortunately, full adoption of such platforms by professional scientists is hindered by mistrust and institutionalized reward systems (e.g., citation statistics) that maintain the status quo. We argue that adopting and encouraging use of democratized modes of internet-enabled communication will increase the equality of scientific information dissemination and accelerate scientific progress, including in limnology and oceanography.

### **Continued inequality in scientific information dissemination**

Scientists remain incentivized by their institutions to communicate their science primarily through the publication of research articles, which are often inaccessible to the public due to field-specific technical language and/or journal paywalls. Science journalists working for major media corporations or local newspapers distill these works and translate scientific findings for the public, but may focus on a subset of scientific topics that are tailored to their consumers (often middle to high socioeconomic strata) and not representative of the field at large (Cacciatore et al. 2014). Furthermore, the rise of the internet has reduced the budget of many traditional broadcast media sources, often cutting science coverage and leaving a void for scientific dissemination to the public (Brossard 2013).

The internet creates a unique opportunity for scientists to directly engage with the public around scientific topics. Indeed, a vast majority of the public now turns to the internet when seeking information (Brossard and Scheufele 2013), often relying on Wikipedia as an introductory source for a number of scientific topics (Dowell and Bridges 2019; Mittermeier et al. 2019). Wikipedia enables the sharing of free scientific information to anyone with an internet connection, creating a powerful platform to increase our collective knowledge as a scientific community and disseminate our knowledge more equitably to the public.

Despite the option for disseminating science more equitably to the public through Wikipedia, scientists rarely prioritize improving scientific topics on Wikipedia. We argue for a dual

bottom-up (i.e., grassroots) and top-down (i.e., societal, institutional) effort in our scientific community to prioritize contributions to freely accessible platforms. In doing so, we must reject warnings from established scientists that scientific information on Wikipedia is less or unreliable (Wilson and Likens 2015), as warnings about the accuracy of Wikipedia content are incorrect. While a few scientific articles may be controversial and subject to competitive editing (e.g., climate change), the majority of topical pages on Wikipedia suffer from omission of information rather than misinformation (Mesgari et al. 2015; Shafee et al. 2017), and policies to ensure accuracy continue to evolve (Harrison 2020). Impressively, the highest quality Wikipedia articles require 5–10 peer reviews (Shafee et al. 2017). Stereotypes about the accuracy of information on Wikipedia also perpetuate a culture that creates unequal distribution of knowledge, benefiting the privileged (e.g., publishers, wealthy universities, scientists with privileged identities and access) while neglecting or oppressing others (e.g., members of the public, poorer universities, minoritized scientists). Because people already turn to Wikipedia for reliable scientific information, it is time that scientists and societies prioritize contributions to the world's most comprehensive encyclopedia.

### **Those who speak on Wikipedia are heard**

Wikipedia leverages collective knowledge and the internet's structure to broadly disseminate accurate and free scientific information. Wikipedia is the largest open-access project in the world, comprising over 300 languages. Wikipedia belongs to the larger Wikimedia Foundation, which includes cross-communicating projects like Wikidata that encode human- and machine-readable structured data; Wikimedia Commons, which contains millions of free media files; and Wikispecies, which aims to archive information on all species identified on Earth.

Information included in Wikimedia Foundation projects is highly discoverable because search engines use Wikipedia and its affiliated projects as authoritative sources of information to populate infoboxes in panels above web search results (McMahon et al. 2017). Additionally, Wikipedia articles are often the top page return in search queries, making it one of the most visited websites in the world. In terms of readership, a typical Wikipedia article receives around 10,000 pageviews per year, and a Wikipedia article in the 95<sup>th</sup> percentile of readership receives around 1,000,000 pageviews per year (Shafee 2017). Because Wikipedia is both accessible to and editable by anyone with internet access, this platform has great promise for broad dissemination of scientific information in the internet age where dissemination is a question of *who gets heard*.

### **Aquatic information on Wikipedia**

Unfortunately, limnology- and oceanography-related Wikipedia articles are in poor condition. For example, as of

05 May 2020, the English Wikipedia article for *Hypolimnion*<sup>1</sup> was only six sentences long and contained no references yet had been viewed over 11,000 times per year on average since 2015. In response to inadequate representation of aquatic information on Wikipedia, one of the world's most visited websites, a group of early career aquatic scientists established WikiProject Limnology and Oceanography (WP L&O) at the 2018 Ecological Dissertations in the Aquatic Sciences (Eco-DAS) symposium.<sup>2</sup> A WikiProject is a group of editors that works together to improve Wikipedia, generally focused on a specific topic. The scope of WP L&O is any Wikipedia article relating to the study of inland waters or marine environments, encompassing lakes, ponds, reservoirs, streams, rivers, wetlands, groundwater, estuaries, and oceans. At the time of writing this article, there were >770 English Wikipedia articles under the scope of the project, and the project continues to grow. Collectively, these articles have received an average of >125,000 views per day in recent months. Through recruiting new editors and hosting five "edit-a-thons" (focused editing time), WP L&O has added over 50,000 words to limnology- and oceanography-related Wikipedia articles; however, more than 60% of the articles assessed for the project remain in poor condition and lack references, have poor structure, or are missing crucial information.<sup>3</sup>

### ***Toward more equitable aquatic information dissemination through Wikipedia***

Untapped potential exists for leveraging Wikipedia to make aquatic science information dissemination more equitable. The Wikimedia Foundation has long-term archival commitments and Wikipedia represents an extraordinary opportunity to literally rewrite the aquatic disciplines to be more inclusive of diverse viewpoints while also being the go-to introductory aquatic resource that is both versioned and updatable. Historically, textbooks and print encyclopedias have been largely written by white men, and often omit achievements from minoritized individuals and/or perpetuate negative stereotypes of notable achievements from underrepresented groups. This vicious cycle of underrepresentation has continued on Wikipedia, where to date, only ~18% of biographies are of women, in part because the Wikipedia editor base still has low gender, racial, and geographic diversity. Some scientist editors are actively fighting these biases. For example, physicist Dr. Jessica Wade has written over 1000 Wikipedia biographies of underrepresented scientists (Kramer 2018), and aquatic biogeochemist Dr. Rebecca Barnes incorporates Wikipedia editing of biographies for women in STEM in undergraduate courses

<sup>1</sup><https://en.wikipedia.org/w/index.php?title=Hypolimnion&oldid=847753308>.

<sup>2</sup><https://www.aslo.org/eco-das/>.

<sup>3</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Limnology\\_and\\_Oceanography/Assessment](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Limnology_and_Oceanography/Assessment).

using Wiki Education (Villeneuve 2019). These efforts increase the discoverability of these scientists by audiences such as journalists, politicians, and prospective graduate students. Although the number of Wikipedia biographies of underrepresented aquatic scientists is growing, many more could be written.

Biases on Wikipedia reflect the biases of content creators, underscoring the importance of recruiting a diverse editor base for creating aquatic content and continually evaluating biases in aquatic Wikipedia articles. Unfortunately, efforts to reduce systemic biases on Wikipedia, such as creating articles about Black scientists or including perspectives from Sexual Orientation and Gender Identity minorities, can be subject to other editors reverting edits or deleting these articles. These editors often cite Wikipedia "Notability" or "Tone" guidelines to justify their actions (Gauthier and Sawchuk 2017). However, Wikipedia coverage of science topics is driven by the interests of its editors (Halavais 2008), indicating that these editors are simply leveraging Wikipedia guidelines to ensure articles reflect their own biases. Furthermore, new editors or editors attempting to reduce existing biases sometimes receive hostility and harassment from other Wikipedians (Menking et al. 2019), thus perpetuating systemic biases on Wikipedia and in its editor base and ultimately maintaining power for privileged identities (Shaw and Hargittai 2018). The members of WP L&O do not tolerate discrimination or harassment in any form and encourage contributions to aquatic Wikipedia pages to reduce systemic biases. We also warn new editors that harassment can occur when editing, and if harassment does occur, we recommend reviewing Wikipedia's harassment page for actions you can take<sup>4</sup> or reaching out to the WP L&O team via email<sup>5</sup> for help. Other WikiProjects (WP) also focus on reducing biases in Wikipedia coverage, such as WP Black Lives Matter,<sup>6</sup> WP Women in Red,<sup>7</sup> WP Disability,<sup>8</sup> and WP Countering systemic bias,<sup>9</sup> and we encourage aquatic editors to contribute to efforts outlined on these WikiProjects as well.

Equitable dissemination of scientific information must overcome barriers to access (e.g., languages, physical disabilities) and financial barriers. Some physical disabilities relevant to accessing or producing information on the internet include visual (e.g., blindness), auditory (e.g., deafness), motor (e.g., inability to use a mouse), and cognitive disabilities (e.g., learning disability). The standardized structure of Wikipedia helps with page navigation, including expected

<sup>4</sup><https://en.wikipedia.org/wiki/Wikipedia:Harassment>.

<sup>5</sup>[wikipedia@projectlo@gmail.com](mailto:wikipedia@projectlo@gmail.com).

<sup>6</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Black\\_Lives\\_Matter](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Black_Lives_Matter).

<sup>7</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Women\\_in\\_Red](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Women_in_Red).

<sup>8</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Disability](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Disability).

<sup>9</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Countering\\_systemic\\_bias](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Countering_systemic_bias).

**Table 1.** Ways to promote more equitable dissemination of aquatic scientific information through Wikipedia. Promotion can be done by multiple entities (e.g., student, scientist, society) for various goals (e.g., reduce barriers to editing), and achieved by multiple actions (e.g., edit directly, reward contributions).

I am a:	And I want to:	I can:	With these tools:
Scientist, educator, student, scientific society, or work institution	Increase quality, accessible information	Edit directly	3, 4, 5, 18, 21, 22, 24, 28
		Recruit new editors	2, 5, 8
		Host edit-a-thons	8, 11
		Translate or promote translation of articles	6, 7, 23
		Incorporate editing into classrooms	1, 31
Scientist, educator, or student	Improve scientific communication skills	Request training or projects involving Wikipedia	1, 29, 30
		Edit directly	3, 4, 5, 18, 21, 22, 24, 28
Scientist, educator, student, scientific society, or work institution	Reduce barriers to editing	Request training or projects involving Wikipedia	1, 29, 30
		Host editing workshop(s)	5, 8
		Apply for funding to increase free information	2
		Encourage dual publication of journal and Wikipedia articles	12, 13, 25
		Require relevant Wikipedia articles be updated when journal article published	25
Scientist, educator, student, scientific society, or work institution	Assess impact of contributions	Reward contributions	14, 16, 17, 26, 27
		Track contributions of individuals or projects	10, 11, 15
		Assess article quality and popularity	11, 15, 19, 20, 21

1. <https://wikiedu.org/>.
2. <https://meta.wikimedia.org/wiki/Grants:Start>.
3. [https://en.wikipedia.org/wiki/File:WikiProject\\_L%26O\\_Quick\\_Start\\_Guide\\_v1.pdf](https://en.wikipedia.org/wiki/File:WikiProject_L%26O_Quick_Start_Guide_v1.pdf).
4. <https://en.wikipedia.org/wiki/Help:Introduction>.
5. [https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Limnology\\_and\\_Oceanography](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Limnology_and_Oceanography).
6. <https://en.wikipedia.org/wiki/Wikipedia:Translation>.
7. <https://www.translatorswithoutborders.org/blog/the-wikipedia-project-update/>.
8. [https://en.wikipedia.org/wiki/Wikipedia:How\\_to\\_run\\_an\\_edit-a-thon](https://en.wikipedia.org/wiki/Wikipedia:How_to_run_an_edit-a-thon).
9. <https://tools.wmflabs.org/pageviews>.
10. <https://xtools.wmflabs.org/ec>.
11. <https://outreachdashboard.wmflabs.org/>.
12. [https://en.wikiversity.org/wiki/Wikijournal\\_of\\_Science](https://en.wikiversity.org/wiki/Wikijournal_of_Science).
13. [http://topicpageswiki.plos.org/wiki/Main\\_Page](http://topicpageswiki.plos.org/wiki/Main_Page).
14. <https://blog.wikimedia.org/2011/04/06/tenure-awarded-based-in-part-on-wikipedia-contributions/>.
15. <https://xtools.wmflabs.org/>.
16. <https://en.wikipedia.org/wiki/Wikipedia:Barnstars>.
17. [https://en.wikipedia.org/wiki/Template:The\\_Limnology\\_and\\_Oceanography\\_Barnstar](https://en.wikipedia.org/wiki/Template:The_Limnology_and_Oceanography_Barnstar).
18. [https://commons.wikimedia.org/wiki/Commons:How\\_to\\_take\\_pictures\\_for\\_Wikimedia\\_Commons](https://commons.wikimedia.org/wiki/Commons:How_to_take_pictures_for_Wikimedia_Commons).
19. <https://www.mediawiki.org/wiki/ORES/FAQ>.
20. [https://en.wikipedia.org/wiki/Wikipedia:Peer\\_review/guidelines](https://en.wikipedia.org/wiki/Wikipedia:Peer_review/guidelines).
21. <https://tools.wmflabs.org/wikipedia-readability/>.
22. <http://dispenser.info.tm/~dispenser/view/Altviewer>.
23. [https://en.wikipedia.org/wiki/Wikipedia:Multilingual\\_coordination](https://en.wikipedia.org/wiki/Wikipedia:Multilingual_coordination).
24. <https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1000941>.
25. <http://wikiambassador.jiscinvolve.org/wp/2014/03/28/publishing-scholarly-wikipedia/>.
26. <https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1003242>.
27. [https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Molecular\\_Biology/Computational\\_Biology/ISCB\\_competition\\_announcement\\_2013](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Molecular_Biology/Computational_Biology/ISCB_competition_announcement_2013).
28. [https://en.wikipedia.org/wiki/Wikipedia:Manual\\_of\\_Style/Accessibility](https://en.wikipedia.org/wiki/Wikipedia:Manual_of_Style/Accessibility).
29. <https://wikiedu.org/blog/category/wikipedia-professional-development/wiki-scientists/>.
30. <https://www.aps.org/publications/apsnews/202005/wikipedia.cfm>.
31. [https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Limnology\\_and\\_Oceanography/Workshops#Resources\\_for\\_incorporating\\_into\\_classroom](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Limnology_and_Oceanography/Workshops#Resources_for_incorporating_into_classroom).

locations of article links (e.g., *page disambiguation* at top, *external links* at bottom) or navigation with section headings using screen readers. Wikipedia has guidelines and tools for increasing accessibility, such as checking if all images in an article have Alternative text for visually impaired users, subtitles or closed captioning in videos for the hard of hearing, and the *Simple English Wikipedia* that increases access to information for children, people learning English, or those with learning disabilities. Although some of the most prolific Wikipedia editors are blind (Souter 2017), editing Wikipedia can still be difficult for those with visual impairments. Editors working to increase scientific information on Wikipedia should take responsibility to ensure the information is accessible and inclusive, as Wikipedia's accessibility guidelines are often unenforced.

Wikipedia has over 300 language versions, which provide a unique opportunity to coordinate dissemination of open and accurate aquatic information in the native language of nearly everyone on Earth. However, translating Wikipedia articles into multiple languages requires additional effort, and we look to other disciplines for a road map of how to coordinate such efforts. For example, WikiProject Medicine currently coordinates across 42 languages and the medical information on Wikipedia is used more frequently than WebMD (Heilman and West 2015), including by medical practitioners, students, and the public (Shafee et al. 2017). Medical Wikipedia pages have been translated by multilingual editors or with help from organizations such as Translators Without Borders. Translating aquatic information to many languages on Wikipedia increases readership and should promote contributions from scientists and local experts using their own native languages, which can then be translated to other languages and ultimately increase our free and collective knowledge on aquatic resources.

### **How to promote more equitable dissemination through Wikipedia**

Establishing a community that sustainably contributes to and maintains aquatic science information on Wikipedia will require overcoming several major barriers. These barriers include a lack of awareness of Wikipedia's importance for disseminating aquatic information, lack of incentives to contribute, and/or intimidation by the mechanics of editing Wikipedia.

A primary way that individuals can promote more equitable dissemination of aquatic information is by simply editing Wikipedia (Table 1). When you publish a new scientific article, take time to look up Wikipedia pages related to your article and update the content if necessary. If you admire the work done by fellow aquatic scientists, especially underrepresented aquatic scientists, create or improve a Wikipedia page about them. If you are an educator, consider incorporating

Wikipedia editing into your classroom activities (Table 1). If you are not sure what articles most need improvement, visit the WP L&O assessment page<sup>10</sup> to see the current list of articles sorted by article quality; the "Stub" and "Start" articles need the most improvement.

Prioritizing contributions to Wikipedia requires an intentional change in sociocultural norms rather than in the mechanics of doing science. Dissemination of aquatic information will remain inequitable if providing free information is prioritized by only a few. We encourage our scientific societies and institutions to provide incentives for contributing to Wikipedia, such as recognition for Wikipedia contributions, encouragement of dual publication of journal articles and Wikipedia articles, or even requirements for updating relevant Wikipedia pages when scientists publish in society journals (Table 1). Societies and institutions could reward Wikipedia contributions by allowing them to serve as job performance metrics for scientific outreach or broader impacts of scientific grants from agencies like the U.S. National Science Foundation. Because Wikipedia has tools to automatically track contributions through user IDs, real-time article quality assessments, and article pageview analyses, contributions to Wikipedia result in measurable and tractable outcomes that can be used for evidence of broader impacts from both individuals and institutions. Societies and institutions can also pay for formal Wikipedia editing training for scientists to add discipline-specific information to Wikipedia as well as combat systemic biases. Even the most passionate free-information enthusiasts cannot fulfill their duties as aquatic scientists while also sharing aquatic information freely if their efforts are not incentivized by societies and their work institutions.

Lastly, to reduce barriers to editing Wikipedia, WP L&O has provided quick-start guides to facilitate getting started on editing Wikipedia pages.<sup>11</sup> We expect that with aquatic science community involvement, iteration on Wikipedia editing workshops, and feedback given to the Wikimedia Foundation, the barriers to contributing to Wikipedia will be reduced. WP L&O welcomes any feedback on how to reduce barriers to editing Wikipedia and ideas for incentivizing contributions to Wikipedia.<sup>12,13</sup> Through these collective efforts, we expect increased equality of aquatic science dissemination and an acceleration of the sciences of limnology and oceanography.

<sup>10</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Limnology\\_and\\_Oceanography/Assessment](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Limnology_and_Oceanography/Assessment).

<sup>11</sup>[https://en.wikipedia.org/wiki/Wikipedia:WikiProject\\_Limnology\\_and\\_Oceanography](https://en.wikipedia.org/wiki/Wikipedia:WikiProject_Limnology_and_Oceanography).

<sup>12</sup>[https://en.wikipedia.org/wiki/Wikipedia\\_talk:WikiProject\\_Limnology\\_and\\_Oceanography](https://en.wikipedia.org/wiki/Wikipedia_talk:WikiProject_Limnology_and_Oceanography).

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## Conflict of Interest

None declared.

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