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Waterton, Claire, Toogood, Mark ORCID: 0000-0003-2403-0338 and Heim, Wallace (2019) Women in Freshwater Science - Invisible Histories? Marine and Freshwater Research . ISSN 1323-1650

It is advisable to refer to the publisher's version if you intend to cite from the work.
http://dx.doi.org/10.1071/MF18462

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Women in Freshwater Science – Invisible Histories?

Journal:	*Marine and Freshwater Research*
Manuscript ID	MF18462
Manuscript Type:	Comment/Response
Date Submitted by the Author:	03-Dec-2018
Complete List of Authors:	Waterton, Claire; Lancaster University, Centre for the Study of Environmental Change, Sociology Department Toogood, Mark; University of Central Lancashire, FAS Heim, Wallace; Low Wood, Haverthwaite
Keyword:	freshwater

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Women in Freshwater Science – Invisible Histories?

Additional keywords: gender, inequality, freshwater science, history of science.

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It is a lamented truism that women in in science, technology, engineering, mathematics and medicine (STEMM) face barriers in their education and difficulties in breaking through glass ceilings in their careers. Women also make up less of scientific workforces. In the UK in 2017, for example, estimates of the percentage of STEMM posts held by women range from 15-23% (Price Waterhouse Cooper 2017, WISE 2018). This situation is paralleled in Australia, the wider European Union and North America (Jones and Hawkins 2015). Moreover, this underrepresentation is greatest in later, more senior career stages. For example, in natural and physical sciences in Australia a 2016 study found that at undergraduate level, women make up over 50 percent of students (SAGE 2016). At PhD level, representation of women and men was about even. However, in professional science grades, women were underrepresented: 47.1% of junior academics were women and only 16.3% of senior positions were held by women (SAGE 2016). In the UK, women occupy 13% of management positions in STEMM (WISE 2018). This vertical segregation parallels other contexts such as in the European Union (Caprile *et al.* 2012).

Women scientists should rightly be recognised because of the merit of their professional achievements, like the marine ecologist Emma Johnston of UNSW, for example. However, for some women scientists, even the highest scientific achievement does not necessarily correspond to academic career standing. A case in point is Donna Strickland who became only the third woman in history to receive the Nobel Prize for physics in 2018. Upon the announcement of this award for her work on ultra-short laser pulses, her status as an Assistant rather than full Professor attracted most press attention and debate.

There are all sorts of reasons for this situation, ranging from scientific culture itself, to the construction of gender within scientific roles; from the socialisation of young women in education, to low pay, lack of opportunities, and relatively precarious and slow career progression for women in STEMM professions. Yet, despite knowledge of these reasons, women in the history of science are in the curious position of being regarded as either wholly extra-ordinary, or invisible. The effect of this is an acknowledgement that (super-talented, highly notable) women scientists are thin on the ground, leading to a false conclusion that women are justifiably absent from the history of science. We suggest that we need to tell more ordinary 'herstories' of science. We need, that is, to tell the stories of women scientists who are generally unacknowledged - to adopt an historical perspective that recognises that not all women scientists working in the twentieth century were exceptional, but that their part in science should be made visible nevertheless.

We are not alone in suggesting that, historically, the research of women scientists has frequently been conducted in the face of a general lack of opportunity and overt official

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and unofficial discrimination much more prevalent than that which we witness today. When women in the nineteenth and early twentieth centuries were, however, given opportunities to access scientific education and work they often seized it, sometimes in the face of opposition. One example of this is the Balfour Biological Laboratory for Women, established at Cambridge University between 1884-1914 which educated women who were directly excluded from scientific education at Cambridge (Richmond 1997). A further example is the range of hidden histories of women scientists who, during the First World War, became doctors, chemists developing weapons, biologists studying pathogens and mathematicians working in signals and ciphers (Fara 2015; 2018).

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Of course, there is now awareness of examples of women scientists' work being ignored and obscured from the historic record. The example of Eunice Foote from the nineteenth century has become something of a cause celebre. Foote read a short paper about her experiments on solar heat absorption by climate gases to the August 1856 meeting of the American Association for the Advancement of Science (AAAS) (Foote 1856). This presentation (women were not permitted to publish full papers), apparently received only polite and patronizing acknowledgement, partly perhaps because she was, after all, not a full AAAS Fellow; women's scientific status allowed them only membership (Warner 1978). John Tyndall's similar theory published a few years later, omitted to acknowledge Foote's experimental and theoretical work, (Tyndall 1859; 1861). Tyndall has subsequently gained recognition as the first theorist of climate change.

Research has revealed how women with scientific training and qualifications in the twentieth century were subtly and not-so-subtly steered towards editing, teaching and librarianship, and away from the laboratory and the field (Des Jardins 2010). They were frequently relegated to repetitive, relatively low status scientific tasks, that would have frustrated men with comparable scientific training. Their careers were also held back by the assumption that marriage required them to resign from their scientific posts (this 'marriage bar' was official policy in the UK until 1946 and in British colonies until the mid-1950s). If we recognise such women scientists who managed to deal with and, even, flourish in such a climate and can tell their stories, then we should reveal detailed and a more nuanced history of (women) scientists and science.

To take our own area of research interest, the history of women in freshwater science is a case in point. Our archival research into gender and science at the Freshwater Biological Association (FBA) shows that the freshwater sciences provided opportunity for women during the first half of the twentieth century when science was widely segregated by gender. In the context of the UK, at least 20 women were working or training at this institution in its early years before and after the Second World War. The FBA was part of a network of universities, and colonial and Commonwealth science providing openings for women scientists in then novel and expanding aquatic sciences. There are some specific, largely biographical, accounts of the history of particular aquatic sciences (see Balon et al, for example), but none that focus on women scientists and the cultures of research they entered and helped create.

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We can give some examples of these women here. Penelope Jenkin, graduated from Cambridge University in freshwater biology in 1925 – although Jenkin would have received a certificate rather than a degree as Cambridge did not award degrees to women until 1948 (Dyhouse 1995). Jenkin was encouraged by her supervisor at Cambridge, John Saunders, who also was on the FBA Council. Her research on the zooplankton of Windermere, started in 1932, has a claim to be the first research undertaken at the FBA, yet, apart from the eponymous sediment corer named after her, little is known about Jenkin's career, her interactions with other scientists at the FBA, and whether she influenced other women to get into science, for example.

Marie Rosenberg arrived at the FBA in 1934 to conduct research into aquatic algae (Anonymous 1936). In January 1938, she became the first female to obtain a permanent paid naturalist position. Despite this status, as an Austrian émigré she was interred early in the Second World War and, after a year in a camp on the Isle of Man, strict official requirements meant she had to leave the FBA as it was geographically located in a coastal county. Although little is known of her career after that, it seems that she did not depart the freshwater science network, however, and moved to work at Saunders' Cambridge laboratory, possibly in late 1941 or early 1942.

In 1939, Winifred Frost, an ichthyologist, became the second full-time female professional naturalist at the FBA (Anonymous 1939). Frost and her protégé Rosemary Lowe's field and experimental work on eels (*Anguilla anguilla*), including on otoliths, produced a thorough understanding of the autecology of the species. Winifred Frost

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notably went on to collaborate with Charlotte Kipling and Margaret Brown on Salmonidae (Frost and Brown 1967).

A woman scientist from the FBA who has achieved a certain amount of wider recognition is Winifred Pennington, who first came to the FBA in 1936. Her early explorations of lake sediments in Lake Windermere became "the seedbed for the flowering of British limnology" (Lund 1984, 2), and her later wartime and post-war work on post-glacial vegetation changes was pioneering in the field of paleolimnology (Pennington 1943, 1947).

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We could continue to list more women freshwater scientists from the inter- and post-War period who worked at the FBA, such as Hilda Canter, Vera Collins, Elizabeth Howarth, Brenda Knudson, and Peggy Varley, who, outside of their specific fields are unacknowledged and, importantly, whose founding roles as scientists and as women in a particular scientific culture are generally unexplored. We do not know, for example, whether FBA women scientists were subject various phenomena described by the sociology of science. For example, the 'Matthew effect' (Merton 1968), defines the way social and cultural process in science confer cumulative advantages for male scientists of opportunity, recognition and enhancement, thereby disadvantaging women. Another issue to explore was whether women freshwater scientists were subject to the comparable 'Matilda effect' – in which male scientists take credit for women scientist collaborators' work - impacting upon their achievement (Rossiter 1993). Lastly, and perhaps the ultimate definition of historical invisibility, is the converse of the 'scientific pipeline', the 'vanish box principle', a metaphor that describes women who drop-out, or are pushed out of scientific careers (Etzkowitz *et al.*2000). This could apply to scientists whose lives and work we are interested to trace, such as Marie Rosenberg.

These scientific lives are increasingly gaining attention, yet the history of science still tends to isolate women scientists, rather than think of women working in scientific cultures. The aquatic sciences have, it seems, a rich history. It is about time to open these up, to simultaneously consider science and women in the twentieth century, and more recently, and to define their wider significance.

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Funding This research did not receive any specific funding.

Conflicts of Interest The authors declare no conflicts of interest.

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