Women in Freshwater Science – Invisible Histories?

C.F.J Waterton[A], M.D. Toogood[B], and M.W. Heim[C]

[A] Centre for the Study of Environmental Change, Sociology Department, Lancaster University, LA1 4YT, United Kingdom.

[B] Historical Geography, University of Central Lancashire, Preston, PR1 2HE, United Kingdom.

[C] Low Wood, Haverthwaite, Ulverston, Cumbria, LA12 8LY, United Kingdom.

Abstract. Women scientists have historically been subject to direct and indirect discrimination. This opinion piece argues for a history of freshwater science that recognises the scientific achievements of women. It suggests that lack of opportunity for women scientists in the twentieth century is typified by the stereotype that women were naturally predisposed to non-intellectual pursuits and, therefore, ill fitted to science. Freshwater science in Britain possibly provided a distinctive space for women in science in spite of widespread lack of opportunity. Over 20 women scientists were working in one institution in the interwar period, and during and immediately after the Second World War. Yet outside of that specific context their work is barely known. We give examples of these women and their work and argue that the historical invisibility of women in aquatic sciences needs to be more thoroughly addressed in order to understand the work of women scientists as having historical, social, as well as scientific, significance.

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

Introduction.

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. 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, a disproportionate amount of media attention seemed to focus on her career grade rather than her scientific achievement (Stack 2018).

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 unequal 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 either standout geniuses, or invisible (Kass-Simon and Farnes 1990). 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. Contrary to this, we suggest that we need to tell more ordinary 'herstories' of science. We need, that is, to avoid searching the archives for uniquely talented women scientists, and make more visible what we can glean about those women whose work has been important, constructive and valuable within specific scientific contexts. Through our ongoing research, "Gender and Science through the Archives of the Freshwater Biological Association", we are attempting to bring such narratives to light.

Lack of scientific opportunity for women.

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 and unofficial discrimination much more prevalent than that which we witness today (Des Jardins 2010, Abir-Am and Outram 1987). When women in the nineteenth and early twentieth centuries, however, were 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).

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 scientific drudgery: 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) (Mccarthy 2009). 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.

Women in freshwater research

We now draw on our own research to pursue the arguments and suggestions made above through the history of women in British freshwater science. Our archival research into gender and science at the Freshwater Biological Association (FBA), founded in 1929, 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 of colonial and Commonwealth science organisations - that provided openings for women scientists in the then novel aquatic sciences. Whilst there do exist some specific, largely biographical, accounts of the history of particular aquatic sciences (see Balon et al, 1994, for example), none of these focus on women scientists and the cultures of research they entered and helped create. Hence we have the opportunity to bring to bear new stories and insights about the role that women scientists played in this new scientific institution.

We give examples of the work of several of these women here. Some of these instances are of women who surmounted challenges and achieved success. Other individuals are harder to assess than their contemporaries, having abandoned their scientific research.

One of the key conduits for affording these scientists opportunities in the Freshwater Biological Association's early days was the annual "Easter class" held for students from across the UK and beyond. Two of these young scientists in the 1930s, Maud Godward and Carmel Humphries, went on to have notably distinguished academic careers.

Godward was a freshwater phycologist and carried out postgraduate research at Lake Windermere with the FBA. This experience gained her employment as a lecturer at Queen Mary College, University of London. She became a founding member of the British Phycological Society in 1953 and went on to gain a Chair in Phycology at Queen Mary's. A fellow of Godward's at the FBA was Carmel Humphries, who worked on benthic fauna (Humphries 1936). She also benefitted from her experiences at the FBA, becoming a lecturer at University College Dublin. She was made professor of zoology there in 1957 and frequently returned to the FBA to conduct her research on chironomids.

In 1939, Winifred Frost, an ichthyologist, became the second female full-time professional naturalist at the FBA (FBA 1939). During her career she collaborated with many other women scientists, devising innovative experiments and programmes of research, and extending networks globally from her empirical sites around lake Windermere. Together with her research assistant, Rosemary Lowe, she created an innovative programme of research into eels (*Anguilla anguilla*) during the years 1939-1944 (Frost 1945, 1946; Bagenal 1970). Their wartime experiments utilised a home-made tank they called 'the River Styx' to investigate the young elvers' relationship to different light sources and intensities. Winifred Frost was often the only permanent member of scientific staff left at the FBA when male scientists were away serving in the armed forces. She went on to collaborate with Charlotte Kipling and Margaret Brown on Salmonidae (Frost and Brown 1967) and her experimental work on eels, including on otoliths, produced a thorough understanding of the autecology of the species (Frost 1945, 1946, Lowe 1952). Rosemary Lowe went on to research tiliapids in tropical freshwater systems. Her work is acknowledged to have “revolutionized global studies on freshwater ecosystems and fish production” (Reid 2016, 443).

Penelope Jenkin, graduated from Cambridge University in freshwater biology in 1925 – although she would have received a certificate rather than a degree as Cambridge did not award degrees to women until 1948 (Dyhouse 1995). Supported by her supervisor at Cambridge, John Saunders, who also was on the FBA Council (Anonymous 1933), she began research on the zooplankton of Windermere in 1932. This was, in fact, the first research undertaken at the FBA, yet, few details are yet known about her apparently diverse career, her collaborations with other scientists and her contributions to life and work at the FBA (Lund and Monaghan 2000, Jenkin 1942, 1962). We do know that she was among the first women to get a postgraduate degree from Cambridge University after 1948 when it finally awarded degrees to women. She also continued her work on diatoms in the marine environment, going to work at the Marine Biological Association in Plymouth in the late1930s (Haines 2001).

Marie Rosenberg achieved her doctorate at the University of Vienna in May 1930. In July 1932 she was appointed to a research post at the Institut für Strahlenforschung (Institute of Radiation Research) at the University of Berlin where she conducted her own independent research including into freshwater algae. A year later the Nazis were in power and she, like many other academics of Jewish descent, received a seven-line communication from the university declaring that she was ‘nichtarischen’ (non-Aryan) and therefore her post would ‘aufgeben müssen’ (have to be given up). Marie stayed in Berlin the rest of the summer of 1933. She made contact with the newly established

Academic Assistance Council (AAC) run by Tess Simpson, a pacifist Quaker from Leeds (The Times 1996). The AAC made an award to Marie that allowed her to come to London in October 1933. The AAC also functioned as an academic labour exchange of sorts and, through that connection, Marie was invited by Professor Dame Helen Gwynne-Vaughan to work in the Botany Department at Birkbeck College, University of London. As luck would have it, Helen Gwynne-Vaughan was a life member of the FBA. This connection facilitated Marie to first conduct research on freshwater algae, then to receive a studentship (which she held between 1935 and 1937, working alongside Penelope Jenkin) (Freshwater Biological Association 1936). In January 1938, she became the first female to obtain a permanent paid Assistant Naturalist position, focusing on Algology. After the outbreak of war, however, in June 1940, north Lancashire was declared a 'protected area' and, consequently, and certainly paradoxically, Marie was interned as an enemy alien. Campaigning by FBA colleagues and applications by the Royal Society and the successor organisation to the AAC, the Society for the Protection of Science and Learning, led to her release in January 1941. The freshwater science network supported Marie throughout her ordeal. The occasion of her liberty was commemorated in doggerel verse by her FBA colleague, Thomas Macan:

'Twas not for crime that Rosie was doing time;
I know it sounds tyrannic
But celebrated British phlegm
In times of stress deserted them,
They got into a panic

And gathered in the high and low
And locked them up both friend and foe,
Selection uninvidious,
And as they shut the prison doors

They shouted ‘Freedom is our Cause’,
Oh, Albion Perfidious!
(Macan 1941, 23)

Although relatively little is yet known of Rosenberg’s career after 1941, it seems that she was unable to continue work on the ecology of phytoplankton. She did not depart the freshwater science network, however, and moved to the Botany School in Cambridge laboratory in early 1942, publishing at least once more paper on freshwater algae before – we think – retiring from freshwater research (Rosenberg 1942).

Another friend of Marie Rosenberg’s was the Cambridge marine biologist, Anna Bidder whose father, George Bidder, was a FBA life member and also a marine biologist. Bidder’s mother was Marion Greenwood, supervisor of the aforementioned Balfour Biological Laboratory at Cambridge University. It seems likely that Anna Bidder and her father provided assistance to Marie Rosenberg when she arrived in Cambridge from Windermere. Anna Bidder also had another connection to FBA women scientists. One of her many achievements was the co-founding in 1955 of Lucy Cavendish College at Cambridge University, the only college for graduate women students. She became its first President, 1965-1970, and her successor as the second President was the FBA freshwater scientist, Kate Ricardo.

Winifred Pennington, who first came to the FBA in 1936 has received wider recognition than the previously mentioned women scientists. Her early explorations of lake sediments in Lake Windermere are reported to have become “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). After a period at Cambridge University Pennington returned to the FBA to serve on the FBA Council between 1958-1967. In 1967 she became a permanent member of staff, founding the Quaternary Research Unit there.

Conclusion

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 roles as scientists and as women in a scientific culture are generally unexplored. We do not know, for example, whether FBA women scientists were subject to 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 these have historically conferred opportunity, recognition and enhancement, thereby disadvantaging women. Another issue to explore is 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 'leaky pipeline', a metaphor that describes women who drop-out, or are pushed out of scientific careers (Etzkowitz *et al.*2000).

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.

Conflicts of Interest The authors declare no conflicts of interest.

Acknowledgements This research did not receive any specific funding. We wish to acknowledge the support and assistance of the following: Dr Bill Brierley and Dr Anne Powell, OBE, respectively Chief Executive and Vice President of the Freshwater Biological Association; and, Dr Isabelle Charmantier of the Linnean Society of London. We also thank Dr Agneta Burton for access to documents in her keeping relating to her mother, Dr Marie Rosenberg.

References

Abir-Am, P. and Outram, D. (1987). 'Uneasy Careers and Intimate Lives: Women in Science, 1787-1979.' (Rutgers University Press: New Brunswick).

Balon, E.K., Bruton, M.N., and Noakes, D.L.G. (Eds) (1994). 'Women In Icthyology: An Anthology in Honour of ET, Ro and Genie, Reprinted from *Environmental Biology of Fishes* with additions.' (Springer: Dordrecht.)

Caprile, M., Addis, E., Castaño, C., Klinge, I., Larios, M., Meulders, D., Müller, J., O'Dorchao, S., Palasik, M., Plasman, R., Roivas, S., Sagebiel, F., Schiebinger, L., Vallès, N., and Vàzquez-Cupeiro, S. (Eds) (2012). Meta-analysis of gender and science research. EU Directorate-General for Research and Innovation synthesis report, Luxembourg.

Des Jardins, J. (2010). ‘The Madame Curie Complex: The Hidden History of Women in Science.’ (The Feminist Press: New York City.)

Dyhouse, C.A. (1995). ‘No Distinction of Sex? Women in British Universities, 1870-1939’. (Routledge: London.)

Etzkowitz, H., Kemelgor, C., and Uzzi, B. (2000). ‘Athena Unbound: The Advancement of Women in Science and Technology.’ (Cambridge University Press: Cambridge).

Fara, P. (2018). ‘A Lab of One’s Own: Science and Suffrage in the First World War.’ (Oxford University Press: Oxford.)

Fara, P. (2015). Women, science and suffrage in World War I. *Notes and Records: The Royal Society Journal of the History of Science* **69**, 11-24.

Foote, E. (1856). Circumstances affecting the heat of the sun's rays. *The American Journal of Science and Arts* **22**, 383–384.

Freshwater Biological Association of the British Empire, (1933). Freshwater Biological Association of the British Empire, Fourth report of Council, subscription list and accounts for 1933. List of officers and Council for 1933. (FBA: Ambleside.)

Freshwater Biological Association of the British Empire, (1936). Freshwater Biological Association of the British Empire, Fourth report of Council, subscription list and accounts for the year ending 31 March 1936. (FBA: Ambleside.)

Freshwater Biological Association of the British Empire, (1939). Freshwater Biological Association of the British Empire, Seventh report of Council, subscription list and accounts for the year ending 31 March 1939. (FBA: Ambleside.)

Frost, W.E. (1946). Observations on the food of eels (*Anguilla anguilla*) from the Windermere catchment area. *Journal of Animal Ecology* **15**, 43-53.

Frost, W. (1945). The age and growth of eels (*Anguilla anguilla*) from the Windermere catchment area **14**, 26-36.

Frost, W.E., and Brown, M.E. (1967). ‘The Trout.’ (Collins: London.)

Haines, C.M. (2001). ‘International Women in Science. A Biographical Dictionary to 1950.’ (ABC-CLIO: Santa Barbara.)

Humphries, C.F., (1936). An investigation of the profundal and sublittoral fauna of Windermere. *Journal of Animal Ecology* **5**, 29-52.

Jenkin, P. (1962). ‘Animal Hormones: A Comparative Study.’ (Pergamon Press: Oxford.)

Jenkin, P. (1942). Seasonal changes in the temperature of Windermere (English Lake District). *Journal of Animal Ecology* **11**, 248-269.

Jones, C., and Hawkins, S. (2015). Guest editorial – women and science. *Notes and Records: The Royal Society Journal of the History of Science* **69**, 5-9.

Kass-Simon, G. and Farnes, P. (Eds) (1990). 'Women of Science: Righting the Record.' (Indiana University Press: Bloomington.)

Kirkup, G., Zalevski, A., Maruyama, T., and Batool, I. (2010.) 'Women and Men in Science: The UK Statistics Guide 2010.' (UKRC: Bradford).

Lowe, R. (1952.) The influence of light and other factors on the seaward migration of the silver eel (*Anguilla anguilla* L.). *Journal of Animal Ecology*, **21**, 275–309.

Lund, J. (1984). Winifred Tutin: a personal note. In '*Lake Sediments and Environmental History'*. (Eds E.Y. Haworth and J.W.G. Lund), pp. 1–10. (Leicester University Press: Leicester.)

Lund, J. and Monaghan, E. (2000.) Dr P. M. Jenkin and the earliest days of the FBA's laboratory at Wray Castle. *Freshwater Forum* **13**, 2-15.

Macan, T.T. (1941.) Recollections of the Freshwater Biological Association, or what you will not find in the annual report. FBA, unpublished report, Ambleside.

Mccarthy, H. (2009.) Petticoat diplomacy: the admission of women to the British Foreign Service, *c.*1919–1946. *Twentieth Century British History* **20**, 285–321.

Merton, R.K. (1968). The Matthew effect in science. *Science* **159**, 56-63.

Pennington, W. (1943). Lake sediments: the bottom deposits of the North Basin of Windermere, with special reference to the diatom succession. *New Phytologist* **42**, 1-27.

Pennington, W. (1947). Studies on the post-glacial history of British vegetation. VIII Lake sediments: pollen diagrams from the bottom deposits of the North Basin of Windermere. *Philosophical Transactions of the Royal Society B* **233**, 137-175.

Price Waterhouse Cooper (2017). Women in Tech: Time to Close the Gender Gap. PwC UK research report. Available at www.pwc.co.uk/womenintech [accessed 23 Nov 2018].

Reid, G. McGr. (2016). Obituary. Rosemary Lowe-McConnell 1921–2014 (Freshwater Biological Association and British Museum of Natural History). *Journal of Fish Biology* **88**, 443-447.

Rosenberg, M. (1942). Chrysochaete, a new genus of the Chrysophyceae, alled to Naegeliella. *New Phytologist* 40

Rossiter, M.W. (1993). The Matthew/Matilda effect in science. *Social Studies of Science* **23**, 325–341.

Science in Australia Gender Equity (SAGE). (2016). 'Gender equity in STEMM, natural and physical science data for Australia.' Available at https://www.sciencegenderequity.org.au/gender-equity-in-stem/ [accessed 2 February 2019].

Stack, M. (2018). Why I'm not surprised Nobel Laureate Donna Strickland isn't a full professor**. *The Conversation* October 5. Available at** https://theconversation.com/why-im-not-surprised-nobel-laureate-donna-strickland-isnt-a-full-professor-104459 **[accessed 16 April 2019].**

Talling, J. F. (2008). The developmental history of inland-water science. *Freshwater Reviews* **1**, 119-141.

The Times. (1996). Obituary of Esther Simpson, November 30.

Toogood, M., Waterton, C., and Heim, W., (forthcoming). Women scientists at the Freshwater Biological Association, 1929-1950. *Archives of Natural History* **47**.

Tyndall, J. (1861). On the absorption and radiation of heat by gases and vapours, and on the physical connexion of radiation, absorption and conduction. *Philosophical Transactions of the Royal Society of London* **151**, 1-36.

Tyndall, J. (1859). Note on the transmission of heat through gaseous bodies. *Proceedings of the Royal Society of London* **10**, 37-39.

Warner, D.J. (1978). Science education for women in antebellum America*. Isis* **69**, 58-67.

WISE (2018). 'STEM workforce statistics 2018.' Available at: https://www.wisecampaign.org.uk/statistics/2018-workforce-statistics/ [accessed 3 Nov 2018].