Institution: University College London

Unit of Assessment: 17B – Geography, Environmental Studies & Archaeology: Geography

Title of case study: The Open Air Laboratories (OPAL) project and its contribution to raising public awareness of, and participation in, freshwater science

1. Summary of the impact (indicative maximum 100 words)

The OPAL Water Centre at UCL, funded to a total of £732k, developed an innovative educational national water survey programme accessible to people of all ages and abilities, promoted especially within disadvantaged communities. Of the more than 45,000 participants, 17% were from 'hard to reach' communities. The Survey encouraged greater understanding of the aquatic environment through public participation in water quality and aquatic biodiversity assessment and used high-quality research to link the community, voluntary and statutory sectors by creating a channel through which locally derived information could lead to site-specific management as well as national and international policy.

2. Underpinning research (indicative maximum 500 words)

The Department of Geography at University College London (UCL) has a long history of research on pollutant (trace metals and persistent organic pollutants; POPs) distribution within aquatic ecosystems and their biotic effects (Rose, Turner, Yang) and also freshwater ecological assessment using aquatic biota (Goldsmith, Davidson). These two bodies of research underpinned the roles of UCL researchers as leads for the OPAL Water Centre (hosted at UCL), a component of the Open Air Laboratories (OPAL) network led by Imperial College.

Between 1994 and 2003 we coordinated and managed a series of EU-funded projects on remote lakes (AL:PE2; MOLAR; EMERGE: Battarbee, Kernan, Patrick), which provided evidence for latitudinal and altitudinal changes in pollutant input across broad geographical scales; for the effects of trophic status of pollutant uptake in cold, oligotrophic waters; and for the presence of contaminants at considerable concentrations in new geographical regions (e.g. toxaphene in UK [a]). A 2006-09 Leverhulme-funded project (Rose) used lake sediments to determine spatial and temporal patterns across the Tibetan Plateau [b], developing ideas of lake sediment inter-comparisons that were employed within the OPAL monitoring programme. More recently our research elucidated the role of climate change in remobilising pollutants from catchment soils and their transfer to aquatic systems in the context of upland lakes [c]. Regional studies undertaken since 1993 have linked the distribution of trace metals and sourced fly-ash particles for the first time, using lake sediments as spatially arrayed depositional archives (EU Copernicus UCL-led FLAME project 1994–96; Royal Society / Chinese Academy of Sciences projects, 1992–94; 1998–2001) (Rose). Distribution of pollutants (metals, POPs, fly-ash) and their impacts within aquatic systems was a theme continued at the national level by OPAL and led to the monitoring and assessment of contaminants in 9 lakes across England [d, e] by the OPAL Water Centre, and the national OPAL Metals Survey.

In addition, the water quality assessment approach used by the OPAL Water Survey was based upon experience gained from UCL-led studies in determining ecological change within freshwaters using contemporary biological indicators (Goldsmith, Davidson). This approach, in which contemporary biota and their sub-fossil remains are used to assess the current and historical ecological quality of freshwaters, is now widely accepted as an established technique amongst statutory monitoring bodies. Our research using macrophytes, diatoms, chironomids and other macrofossils as ecological indicators [f] underpinned the decision to use aquatic invertebrates to assess water quality within the OPAL Water Survey, which employed a simple invertebrate classification scheme allowing participants to allocate a 'pond health' score to any water body without prior training. The resulting data generated by individuals, schools, local interest groups and other organisations provided a 'snapshot' of water quality across England that would otherwise have not been possible, including data for sites that would not have been accessible (e.g. private land) to traditional surveying approaches.

3. References to the research (indicative maximum of six references)

(UCL authors [at time of research] in **bold**)

[a] **Rose, N.L.**, Backus, S., Karlsson, H. & Muir, D.C.G. (2001) An historical record of toxaphene

and its congeners in a remote lake in Western Europe. *Environmental Science & Technology* 35, 1312-1319. doi:10.1021/es0015895. (ISI Journal Impact Factor [JIF]: 5.257; SCOPUS Citations:19)

- Describes the first historical record of toxaphene outside the USA and the first record of individual toxaphene congeners anywhere, aiding the interpretation of other new pollutant records within OPAL.

[b] **Yang, H.**, **Battarbee, R.W.**, **Turner, S.D.** & **Rose, N.L.**, Derwent, R.G., Wu, G & Yang R. (2010) Historical reconstruction of mercury pollution across the Tibetan Plateau using lake sediments. *Environmental Science & Technology* 44, 2918-2924. doi:10.1021/es9030408. (JIF: 5.257; SCOPUS Citations: 23)

- Describes how lake sediment cores may be used as spatially arrayed depositional archives of contaminants allowing regional patterns to be determined, an approach employed within the OPAL project.

[c] **Rose, N.L.**, **Yang, H.**, **Turner, S.D.** & **Simpson, G.L.** (2012) An assessment of the mechanisms for the transfer of lead and mercury from atmospherically contaminated organic soils to lake sediments with particular reference to Scotland, UK. *Geochimica et Cosmochimica Acta* 82, 113-135. doi: 10.1016/j.gca.2010.12.026. (JIF: 4.414; Citations: 4)

- Describes the need for the holistic approach to contaminant record interpretation, employed by OPAL, by showing the importance of lake catchments to metal contaminant inputs.

[d] Harrad, S., Abdallah, M. A-E., **Rose, N.L.**, **Turner, S.D.** & **Davidson, T.A.** (2009) Current-use brominated flame retardants in water, sediment and fish from English lakes. *Environmental Science & Technology* 43, 9077-9083. doi:10.1021/es902185u. (JIF: 5.257; Citations: 33)

- Describes the first records of some brominated flame retardants in English lakes as part of, and continued by, the OPAL monitoring programme.

[e] **Turner, S.D., Rose, N.L., Goldsmith, B.**, Harrad, S. & **Davidson, T.A.** (2013) OPAL Water Centre Monitoring report 2008-2012. 204pp. http://www.opalexplorenature.org/OPAL-water-report

- Describes the outputs of the OPAL monitoring programme.

[f] **Davidson T.A.**, **Sayer C.D.**, **Bennion H.**, David C., **Rose N.L.** & Wade M. (2005) A 250 year comparison of historical, macrofossil and pollen records of aquatic plants in a shallow lake. *Freshwater Biology* 50, 1671-1686. doi:10.1111/j.1365-2427.2005.01414.x. (JIF: 3.931; Citations: 57)

- Describes the use of biological records as indicators of lake water quality, an approach developed further as part of the OPAL Water Survey.

Evidence of the quality of underpinning research is demonstrated by successive peer-reviewed EU funding over 21 years (1991–2012). For example, EMERGE 2000-2003 (EU contract EVK1-CT-1999-00032), UCL funding €362k (**Battarbee**); Eurolimpacs 2004 – 2009 (EU contract 505540), UCL funding €1.5M (**Battarbee / Kernan**). Between 1993-2011 > 500 peer-reviewed scientific papers (including 6 special issues) and 3 books were published based on these EU-funded research projects. Additional funding for trace metal, toxicity and ecological assessment studies were funded by national and regional bodies including Defra and the Environment Agency.

4. Details of the impact (indicative maximum 750 words)

The OPAL Water Centre applied key aspects of the research methodologies and insights outlined above to deliver benefits to non-academic audiences including disadvantaged and traditionally hard-to-reach demographics [see 5 in Section 5, pp. 25–26]. These pertained particularly to public engagement with water science through the OPAL Water Survey, but also, through the parallel research activities at the OPAL Water Centre, to the provision of important water quality data used by policy-making bodies to protect and enhance local and national environments. The Survey, which was launched on 12 May 2010, allowed people of all ages and abilities, but especially disadvantaged communities, to learn about aquatic environments and issues relating to water quality through hands-on science, generating a 'snapshot' assessment of the nation's lake and pond water quality and the first national survey of lake sediment trace metals.

Promoting pupil and public education through water quality surveys: Since its inception, the OPAL Water Centre has distributed 40,000 free water packs, 20,000 of which were sent as class packs to schools. The Centre has particularly encouraged young people to participate in water

science and develop an interest in the natural world via 39 school visits, demonstrations and events delivered by UCL staff over the course of the project. These activities have led, in some cases, to the development of sustainable long-term initiatives supporting children's ongoing engagement with freshwater monitoring and conservation. For example, following a visit to them in 2012, Thames Ditton Junior School, Surrey successfully applied in the same year for a Royal Society Partnership Grant to support their pupils' continued monitoring of local ponds using OPAL Water Survey methods with support from UCL researchers [7]. The school science coordinator said the pupils "were truly enthralled and excited to be taking part in a real scientific investigation" [7]. Other youth organisations benefiting from participation in the project include the Cub Scouts who, in May 2012, adopted a version of the OPAL Water Survey as part of their newly revised 'Naturalist' badge [8]. Water Survey pack contents remain available for free download from the OPAL Water website (http://www.opalexplorenature.org/TakePartWaterSurvey). 17,200 packs had been downloaded by the end of the project in May 2013 [4].

The OPAL Water Survey, the largest lake and pond survey undertaken in the UK, led to widespread media coverage of water science, including publications aimed at young people. It was widely publicised in the national and youth press [3] and by the end of the project data returns exceeded 4,500 representing a > 10% return [4], [5]; 94.7% of survey questionnaire respondents said they had learned something new from it [5, p.31] compared with 89.8% for OPAL overall. Participants also contributed photographs to a national pond-life photo gallery set up by the *Guardian* [3] and over 450 lake mud samples to the supplementary OPAL Metals Survey (May 2010–Dec 2011), to our knowledge the first public participation trace metal survey in the world [4]. Data from this were incorporated into the British Geological Society's G-BASE [4].

Engaging deprived communities with water science: One of the OPAL Water Centre's primary objectives was to facilitate participation in water science among demographics that might not otherwise have the opportunity, by targeting survey distribution and public events within these communities. Of more than 45,000 OPAL Water beneficiaries (who actively took part in activities), 17% were classified as 'hard-to-reach' and included deprived communities, people with special educational needs, victims of domestic abuse and black and minority ethnic groups [5, p. 24–6]. 240 surveys were conducted in the country's 20% most deprived areas, and 483 in areas in the two highest crime domains. Participants included organisations such as the North Norfolk Workout Project, who work with the long-term unemployed, people with physical and mental health problems and adults with learning disabilities [6]; St. Mungo's, an organisation supporting homeless people, and providing drug and alcohol support and physical and mental health care; London Wildlife Trust's 'Budding Together' project (helping people experiencing mental health problems get involved in conservation); and Southwark Youth Offending Services / New Leaf [5, p. 29], as well as Interact (Interfaith Action) an organisation working with young people of different faiths and non-religious beliefs to build understanding and respect through social interaction; and Blackpool's Marton Mere Junior Rangers (area in lowest 5% of Deprivation Indices).

Alongside its educational benefits, one unexpected but gratifying outcome of the project's engagement with these groups has been the many participant testimonies to additional benefits in terms of increased personal wellbeing [5, p. 26]. As one worker from a charity supporting female victims of domestic abuse in the East Midlands explained: "I am dealing with people with mental health issues, such as depression, and spending a few hours out in the open air, doing things they did as kids, has really boosted their confidence" [5, p. 26].

Provision of data supporting local and national governmental environmental interventions: Our research at a lake in each of nine regions of England (2008-12) (see 3 [e], above) undertaken alongside the main public participation surveys enabled local groups to develop conservation policies [1] and also provided key data for the UK contribution to a 2010 consultation on the Stockholm Convention on Persistent Organic Pollutants [2]. This arose from the OPAL Water team's detailed monitoring and research at the 9 lakes providing new data on pollutants listed as Priority Hazardous Substances under the European Union's Environmental Quality Standards Directive (2008/105/EC), such as mercury, PCBs (polychlorinated biphenyls) and brominated flame retardants (3 [e] above).

The report to Defra [2] produced by AEA Technology (an independent scientific consultancy), used OPAL water and fish data to provide evidence for bioaccumulation of hexabromocyclododecane

(HBCD) in UK freshwaters to demonstrate that "values are well above the bioaccumulation criterion... for listing under the Stockholm Convention". It noted that no other UK data were available and made specific reference to OPAL research outputs (3 [d], above), concluding these data provided "ample evidence of bio-accumulation…of HBCD in biota" [2]. HBCD has since been included in the Stockholm Convention for proposed elimination [2].

At a local level, the OPAL Water Centre provided data to Hart District Council to help classify one of the 9 monitoring sites, Fleet Pond (Hampshire), as a failing water body under the EU Water Framework Directive (WFD) and thereby lever funds for a restoration strategy (first phase 2012–15) [5, p. 72]. Hart District Council's Fleet Pond Management Plan 2010-2015 drew on OPAL Water Centre bathymetric, sediment and aquatic biota monitoring survey data [1, p. 77–79]. Dredging of Fleet Pond began in March 2012 on the basis of our data, and these will additionally be used to assess the success of current restoration activities.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[1] For use of OPAL Water data in Hart District Council's (2010) Fleet Pond Management Plan 2010–2015 see p. 77–79 of http://bit.ly/15aL8iH [PDF]. See also *Fleet Pond Blog*, 11 November 2010: http://bit.ly/1gGEq98. Dredging of the pond began in March 2012: http://bit.ly/1aPXIIG.

[2] Broomfield, M., Whiting, R., Lupi, V. and Jones, G. (2010). *Costs and benefits of the addition of hexabromocyclododecane (HBCD) to the Stockholm Convention and the 1998 POPs Protocols*. Report for DEFRA by AEA Technology. AEA/ed56226/Issue Number 5. P19 citing [d]: http://bit.ly/16kcguN [PDF]. Inclusion of HBCD in the Stockholm Convention: http://bit.ly/1a961OM.

[3] Sample coverage of the survey in both national and youth press includes: *National Geographic Kids* 'Becoming a pond detective'. May 2010, Issue 46. Issue 47 (June 2010) included a pullout poster (circulation 70,000); *The Beano* 'How to get a free Water Survey Pack' 26 June 2010. p. 2 (circulation >120,000); *The Guardian online* 'Garden ponds unwittingly polluted by tap water' 10 May 2010 http://bit.ly/1eXsZOO, and 'The Best of Pond Life' 15 June 2010 http://bit.ly/14pb2SA (circ. 1.1 million). *BBC Wildlife Magazine* 'Lucky (pond) dip' May 2011 p. 10–11. (circ. 264,000).

[4] OPAL Water websites: *Water Centre*. Metals survey results; monitoring data for public and simple interpretative summaries of findings. http://www.opalexplorenature.org/WaterCentre. Total hits 93,200 (by May 2013); hit rate 1,500–2,000 a month.

Water Survey results. Data on survey returns; interactive data interrogation using full dataset; photomap of submitted photographs http://www.opalexplorenature.org/WaterSurveyResultsIndex

Figures for downloads and page visits provided by the then Opal website administrator.

Metals data incorporated into G-BASE: http://www.opalexplorenature.org/MetalsSurvey and http://www.bgs.ac.uk/gbase/.

[5] The OPAL Community Environment Report http://www.opalexplorenature.org/CEreport details numbers of beneficiaries; surveys undertaken in deprived areas; case studies and personal testimonies. The report was launched at the House of Lords on 21 January 2013. http://bbc.in/17O7XvQ. Data on the proportion of OPAL Water Surveys in deprived areas and in crime domains provided by OPAL Management Team Coordinator.

[6] A statement about the benefits of project participation to volunteers with physical and mental health problems and adults with learning disabilities has been provided by the Health Projects Officer, The Conservation Volunteers (formerly British Trust for Conservation Volunteers).

[7] A statement about pupil engagement and benefits to students, and about the use of project in developing funding application for Royal Society Partnerships Grant has been provided by the Science Coordinator, Thames Ditton Junior School, Surrey. See also http://bit.ly/18fd88W and the project website describing measurement methods http://bit.ly/1aPZyct.

[8] For the inclusion of the OPAL Water Survey in the new Cub Scout Naturalist badge: http://bit.ly/14pd1WV and http://www.opalexplorenature.org/scout-badge-news.