

## Impact case study (REF3)

<b>Institution:</b> Aberystwyth University		
<b>Unit of Assessment:</b> 14: Geography and Environmental Studies		
<b>Title of case study:</b> Improving quality standards for recreational waters with enhanced data collection and real-time modelling		
<b>Period when the underpinning research was undertaken:</b> 2000-2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Professor David Kay	Professor	1 October 1998- present
Dr Mark Wyer	Postdoctoral Research Assistant	1 September 1999- present
Dr Carl Stapleton	Research Assistant	1 September 1999- present
Dr Lorna Fewtrell	Postdoctoral Research Assistant	1 March 2000- 12 April 2018
Dr Cheryl Davies	Research Microbiologist	1 June 2011- present
<b>Period when the claimed impact occurred:</b> 2015-2020		
<b>Is this case study continued from a case study submitted in 2014? Y/N</b>		
<b>1. Summary of the impact</b> (indicative maximum 100 words)		
<p>Research at the Centre for Research in Environment and Health (CREH) at Aberystwyth University informed the implementation of recreational water quality standards, including revision of World Health Organisation (WHO) and European Union (EU) water quality guidelines and the Environment Agency's (UK-wide) Pollution Risk Forecasting system. Here, CREH provided, for the first time, real-time and within-day predictive modelling, facilitating pollution forecasts that have driven notification procedures and permitted user choice. This improved public safety and safeguarded Blue Flag status. CREH also served as technical adviser for the (world-wide) Blue Flag Awards and for bathing water quality at the 2016 Rio de Janeiro Olympic Games.</p>		
<b>2. Underpinning research</b> (indicative maximum 500 words) 535 words		
<p>Since 2000, the CREH at Aberystwyth University has developed new risk-assessment methodology for bathing water exposures and implemented this at recreational bathing sites across Wales [3.1; 3.2].</p> <p>Article 14 of the <i>Bathing Water Directive</i> (2006) identified two science evidence requirements for the policy community: (i) additional epidemiological information covering both EU fresh recreational waters and Mediterranean bathing sites, and (ii) the use of viral pathogen enumeration as a regulatory tool for bathing waters. Two projects led by CREH addressed these priorities directly: Epibathe (between 2005 and 2008), generated additional epidemiological evidence from EU Mediterranean and riverine fresh water bathing sites [3.6], and Virobathe (between 2005 and 2009), investigated the use of viral pathogen enumeration as a regulatory tool [3.7].</p> <p>Subsequently, Viroclime (between 2010 and 2013), refined the viral enumeration methods and modelled the climate change impacts on pathogens in recreational waters in the EU and Brazil [3.8]. Cloud to Coast (between 2011 and 2015), developed an integrated model to predict the</p>		

exposure to pathogen risks and their health impact assessment, in near-shore coastal waters [3.10].

As a further step, CREH undertook research to underpin the development of new health risk prediction modelling in the Smart Coasts project (between 2010 and 2013) [3.9]. This research integrated modelling of the catchment-scale flux of pollutants from diffuse and point source inputs with detailed hydrodynamic instrumentation and modelling of near-shore waters. This facilitated prediction modelling of health risk to operationalise the WHO and EU 'predict and protect' approach to safe recreational water management, including developing a test site in Swansea Bay, an urban bathing water adjacent to Wales' second-largest city. This represented the first systematic examination and attempt to model significant within-day variability [3.3] in microbial water quality observed at recreational beaches. The sampling underpinning the model development provided a unique granularity of data that suggested an alarming within-day variability in health-related bacterial compliance parameters [3.4]. Although widely considered an artefact of the complex pollution delivery system at Swansea, sampling proved that the 'compliance' outcome for this bathing water could be determined by the time of day chosen to take the sample [3.4]. The resulting modelling and notification system were implemented in 2013 [3.5] and informed WHO recommendations to the EU [3.5].

Given the significant policy-related findings of the Swansea Bay investigations EU Interreg funding of EUR5,100,000 was awarded to test the Swansea Bay findings at other 'at-risk' bathing waters. Acclimatize (between 2017 and 2023) further developed and implemented the risk assessment methodology [3.11]. In 2017, the research focus turned to Cemaes Bay in Anglesey: a small rural bathing water dominated by livestock farming catchments with a small human population, served by a sewage treatment plant discharging a UV disinfected effluent. The daily variability at this rural bathing water was slightly larger than that observed in Swansea Bay, and this was true of other sites examined in 2018 (two bathing waters in New Quay, Ceredigion, 'New Quay North' and 'Traeth Gywn' bathing waters), and then 'Nolton Haven', Pembrokeshire in 2019. The daily variance in water quality mirrored those of Swansea and Cemaes Bays, suggesting such high within-day variability is characteristic of all UK bathing waters.

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

#### Research articles

- 3.1 Pruss, A., Ashbolt, N., Bartram, J., Kay, D. (2004), 'Derivation of numerical values for the World Health Organization guidelines for recreational waters', *Water Research* 38(5), 1296-1304. DOI: [10.1016/j.watres.2003.11.032](https://doi.org/10.1016/j.watres.2003.11.032)
- 3.2 Kay, D., Deere, D., von Sperling, M., and Strauss, M. (2001), Framework for guidelines development in practice, in Fewtrell, L., & Bartram, J., (eds.), *Water Quality: Guidelines, Standards and Health: Assessment of risk and risk management for water-related infectious diseases*. WHO 2001, (London: IWA publications): 395-412. Available: <https://apps.who.int/iris/bitstream/handle/10665/42442/924154533X.pdf;jsessionid=D6052A156D69C05D8C76A6CD5DDE007F?sequence=1>
- 3.3 Wyer, M., Kay, D., Morgan, H., Naylor, S., Clark, S., Watkins, J., Davies, C., Francis, C., Osborn, H., Bennett, S. (2018), Within-day variability in microbial concentrations at a UK designated bathing water: implications for regulatory monitoring and the application of predictive modelling based on historical compliance data, *Water Research* X, 1, 100006. DOI: [10.1016/j.wroa.2018.10.003](https://doi.org/10.1016/j.wroa.2018.10.003)

#### Research reports

- 3.4 Wyer, M., Kay, D., Watkins, J., Davies, C., Francis, C., Kay, C. D., Morgan, H., Naylor, S., Clark, S., Govier, P., Jones, J. L., Palmer, C. (2014), *Faecal indicator source connectivity for inputs to Swansea Bay, South Wales, UK*, (Prifysgol Aberystwyth | Aberystwyth University: Aberystwyth).

3.5 Wyer, M., Kay, D., Naylor, S., Clark, S., Davies, C., Morgan, H., Govier, P., Watkins, J., Francis, C., Osborn, H., Bennett, S. (2013), Statistical modelling of faecal indicator organisms at a marine bathing water site: results of an intensive study at Swansea Bay, UK: A report from the Interreg 4a Smart Coasts – Sustainable Communities Project. (Prifysgol Aberystwyth | Aberystwyth University: Aberystwyth).

#### **Research grants**

3.6 Epibathe: EU-RTD; FP6: (2005-2008): Award: EUR2,100,000: Kay (PI).

3.7 Virobathe: EU-RTD; FP6: (2005-2009): Award: EUR2,600,000: Kay (PI).

3.8 Viroclime: EU-RTD; FP7: (2010-2013): Award: EUR3,200,000: Kay (PI).

3.9 Smart Coasts: EU Interreg via WEFO 4A: (2010-2015): Award: EUR3,700,000, including matched funding - in kind (staff) assistance from AU staff time, Natural Resources Wales & Swansea City Council: Kay (PI).

3.10 C2C Cloud to Coast: NERC: (2011-2015): EU Interreg via WEFO 5A: Award: GBP1,228,472.54: Kay (PI).

3.11 Acclimatize: EU Interreg via WEFO 5A: (2017-2032): Award: EUR5,100,100, including matched funding and project extension: Kay (PI).

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

##### ***Influencing International and UK public policy - providing a scientific basis for recreational water quality standards***

CREH at Aberystwyth University influenced the revision of the WHO 'Guidelines for Safe Recreational Water Environments'. Kay was on the expert drafting group and Fewtrell managed the consultation process and first draft of the expert report agreed in October 2020 [5.1]. Kay and Fewtrell also advised on the revision of the EU Bathing Water Directive (BWD), BWD 2006/7/EU, which sets standards for EU bathing waters and was implemented in the 2015 bathing water season across more than 22,000 European beaches [5.2; 5.3; 5.4]. This benefited significantly the EU coastal tourism sector, which generates EUR183,000,000,000 of gross value added per annum [5.5]. The Lead Scientist directing the WHO Bathing Water Guidelines stated in 2018, that CREH are:

*key members of the WHO technical advisory group on water quality. In this capacity, WHO has drawn on CREH experts to provide an updated review of evidence to inform revision of both EU BWD and WHO guidelines and also to provide rapid technical advice to Member States as needed. [5.2]*

Kay was also recommended by the WHO as a technical adviser to Blue Flag International, the Foundation for Environmental Education (FEE) which administers the world-wide Blue Flag Awards (BFA) for bathing waters. In this capacity Kay responded to multiple technical questions for FEE-BFA [5.6]. A similar WHO recommendation led to Kay acting as the technical adviser on bathing water quality for relevant events at the 2016 Rio Olympics [5.2]. As the technical adviser Kay analysed, and reported the microbial water quality for recreational water events completed in nearshore waters off the beaches surrounding Rio to the organisers of the Rio Olympics and the WHO.

##### ***Improving implementation of Environmental Policy: increasing compliance of recreational waters through predictive modelling and public notification of adverse water quality events***

Scientists from CREH oversaw the implementation of real-time water quality predictive modelling and water management advisory notification approach in Swansea Bay (between 2013 and 2020) and Cemaes Bay, Anglesey, (between 2018 and 2020) [5.7; 5.8; 5.9]. Both of these sites were considered by local communities and experts as 'at risk' of failing EU standards and of de-designation as bathing beaches. GBP100,000,000 of water company investment over many years had not improved Swansea Bay's 'at-risk' classification, and Cemaes Bay failed EU water quality tests in 2016 and 2017. Following the implementation of CREH's water quality modelling,

prediction and notification system, both Swansea Bay and Cemaes Bay passed EU water quality standards and the latter achieved a 'Good' EU classification in 2020. This also protected and enhanced public health as bathers were told in real-time when recreational waters were safe to use, allowing them 'informed choice' as recommended in WHO Guidelines published in 2003 and 2020 (draft), and EU regulations published in 2006 and 2018.

The CREH team worked with Anglesey County Council's task group and Environmental Health Team to support water quality management at Cemaes Bay from 2017. As the Isle of Anglesey County Chief Executive noted in 2018:

*I would like to record my appreciation for your lead and the work you have undertaken with Dr Mark Wyer and your team during 2017, that led to the development of the Bathing Water Prediction Model, which was used successfully during this year's bathing water season.*

*Your involvement with the task group, and continued commitment to provide representation and input in this matter has been invaluable to the Council, and the assistance and support provided to the members of staff from the Environmental Health team when issues have arisen has been greatly appreciated by them. [5.8]*

CREH's predictive modelling was also adopted by the Environment Agency (EA) and other regulatory agencies to model bathing water microbial dynamics and associated health risk. In 2016, the Environment Agency (EA) Science Lead in this area explained the importance of Aberystwyth University's predictive modelling on UK regulatory pollution forecasts:

*I regularly highlight the Smart Coasts Project report to colleagues working in other regulatory Agencies and the policy community ... to shape their understanding of bathing water dynamics and what can be done to model them in an effective way. [5.9]*

The EA has used CREH's multiple regression approach for water quality prediction since 2014 to underpin its Pollution Risk Forecasting (PRF) system at more than 150 bathing waters across the UK [5.9], supporting the Bathing Water Directives short-term pollution provision and warning bathers when water quality standards may not be met, and thereby protecting a bathing site's classification:

*In 2015, using the PRF system, over 23,000 bathing water quality forecasts were made of which approximately 2,400 were warnings. From this, 65 bathing waters had their classification protected ... including 23 sites that would have a deterioration of class... [5.9]*

For the WHO Lead Scientist in this area:

*A particularly novel aspect of WHO Guidelines (2003) and the EU Bathing Water Directive (2006) is the option for regulators to implement real-time prediction of water quality. This is of particular public health benefit because it provides regulators with the option to deliver 'informed choice' to potential bathing water users considering visiting a public bathing water. Development in this area draw on the pioneering work of CREH as reported in the peer reviewed literature (Water Research 2018), the Smart Coasts and Acclimatize project and operational models in daily use in Swansea and Cemaes Bays led by CREH. [5.2]*

CREH's work safeguarded public health and the economies of communities based on tourism [5.10] which '*contributes £4 billion pounds to the UK economy*' [5.11], as bathers are now told in real-time when recreational waters are safe to use, allowing them 'informed choice' as recommended in WHO Guidelines published in 2003 and 2020. Previous models, applied world-wide, use the bathing day as the unit of prediction which incorrectly assumes within-day uniformity in bacterial concentration. AU's predictive modelling produces more accurate water quality predictions. This approach also informed the modelling adopted by the Environment Agency (EA) and other regulatory agencies to model bathing water microbial dynamics and associated health risk [5.9].

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

- 5.1 WHO recommendations for revised bathing water quality guidelines, Bathing Water Directive (2006/7/EC), 11 June 2018. Available at: [www.who.int/water\\_sanitation\\_health/publications/who-recommendations-to-european-water-directive/en/](http://www.who.int/water_sanitation_health/publications/who-recommendations-to-european-water-directive/en/)
- 5.2 Lead Scientist, World Health Organization confirms the relationship between CREH at AU and the implementation of global, EU and UK recreational water quality standards, letter 4 March 2019.
- 5.3 Summary of EU bathing water quality legal obligations under the EU Bathing Water Directive 2006/7/EC. Available at: <https://ec.europa.eu/environment/water/water-bathing/summary.html>
- 5.4 The number of bathing waters in Europe reported to the European Environment Agency for the 2019 season. Available at: [https://ec.europa.eu/environment/water/water-bathing/index\\_en.html](https://ec.europa.eu/environment/water/water-bathing/index_en.html)
- 5.5 European Commission, reports the gross value coastal and marine tourism adds to the economy. Available at: [https://ec.europa.eu/maritimeaffairs/policy/coastal\\_tourism\\_en](https://ec.europa.eu/maritimeaffairs/policy/coastal_tourism_en)
- 5.6 Emails to Kay as a technical adviser for Blue Flag International, between October 2017 and September 2020.
- 5.7 Chairperson Water Health Partnership Wales, Bathing Waters Sub-group and Natural Resources Wales representative confirms the overall contribution to Wales' at-risk bathing waters, letter 22 February 2020.
- 5.8 Executive Officer, Isle of Anglesey County Council (IOCC), confirms the impact of CREH's work at Cemaes Bay, letter 21 November 2018.
- 5.9 Report, UK Environment Agency policy lead on prediction of bathing water quality under the 2006 Bathing Water Directive, 13 April 2016.
- 5.10 Allan George. (2020, November 19), Cemaes Bay now rated as good for bathing water. *North Wales Chronicle*, confirms the impact of local modelling at Cemaes Bay. Available at: [www.northwaleschronicle.co.uk/news/18882955.cemaes-bay-now-rated-good-bathing-water/](http://www.northwaleschronicle.co.uk/news/18882955.cemaes-bay-now-rated-good-bathing-water/)
- 5.11 UK Government press release, Investment in Great British coast is money well spent, March 2016. Available at: [www.gov.uk/government/news/investment-in-great-british-coast-is-money-well-spent](http://www.gov.uk/government/news/investment-in-great-british-coast-is-money-well-spent).