Institution: Swansea University
Unit of Assessment: 7 - Earth Systems and Environmental Sciences
Title of case study: Public understanding of long-distance animal movements: *Great Migrations*

1. Summary of the impact

A device that can be carried by animals for remote sensing was conceived by Professor Wilson at Swansea University in 2005, to enable the tracking of animal movements, energy expenditure and behaviour, and the physical characteristics of their environment. This device has been key to a marked impact on public interest and engagement with a particular area of science; the great migrations of animals. This has been achieved by wide dissemination of findings obtained using the tag, through a range of media platforms; in particular, a seven-part television series enabled by Professor Wilson's device that was accessible to 330 million people in 166 countries. The television series has received much attention from both the press and public, and has influenced the creation of educational online resources and books, and an enhancement of curriculum materials in schools. Furthermore, there have been extensive sales of products associated with the television series, and sales of the remote-sensing tag itself.

2. Underpinning research

To understand how animals operate, it is essential to document their movements, energy expenditure, behaviour and environment. In 2005, Professor Rory Wilson conceived a unique recording device (the 'Daily Diary'; DD) for attachment to wild animals that determined these four cornerstones simultaneously to a hitherto unrealised scale [R1]. In particular, Wilson proposed two new key methodological advances by maximizing synergy in sensor combinations and original analytical approaches [R1]. One advance showed how to determine animal movements via 'dead-reckoning' [R1] (using vectorial calculations on sensors that yielded speed, heading and height/depth data) and avoids the need for the tag to communicate by transmission telemetry. This thus provides a seamless sub-second update on animal 3-D position even when subjects are 'out of sight' (for example, underwater or underground [R1]). The best comparable method, GPS, will only work in air with sight of the sky. The second novelty was creation of a powerful proxy for metabolic rate (dynamic body acceleration [R1-R6]). This metric is derived from tri-axial accelerometers and can be determined instantaneously, and thus applied to determine the cost of wild-animal behaviours over single seconds. The only comparable method, determination of heart rate, is onerous, involving tag implantation, and works, at best, over minutes. In addition, the DD provided various standard metrics which can be used to determine behaviour [R1, R3, R6], and environmental data such as light intensity, humidity and temperature [R1]. Since animal movement and behaviour depend on the environment and are critically dependent on judicious use of energy, the DD represents the first device quantifying and linking these elements together and represents a radical, new approach for understanding the ecology of wild animals.

Grants from National Geographic to fund further DD work [G2, G3], in association with the *Great Migrations* series (see below), led to important discoveries (such as how marine animals use undulating flight to save energy [R5] and how the landscape can be considered in terms of movement costs and how this explains animal landscape use [R6]) that were in turn incorporated into the series.

3. References to the research

The concept for the DD was first recognised for its potential when Professor Wilson was awarded a Rolex Award for Enterprise (2006) (see below) (the formal publication describing it was published in 2008 [G1]). National Geographic awarded grants so that the device could be used to inform its *Great Migrations* series.

Key grants

(All grants awarded to Rory Wilson)

G1: Development of a 'Daily Diary' for Animals. Awarding organisation; Rolex Award for Enterprise, 2006–2010. $100,000

G2: Energetic tricks for a successful migration; secretive studies of vertebrates using new technology. Awarding organisation: National Geographic, 2008–2009, $48,670.

G3: Energetic tricks for a successful migration; secretive studies of vertebrates using new technology. Awarding organisation; National Geographic, 2009–2009, $20,000.

Publications

R1 Wilson, RP et al. (2008). Prying into intimate details of animal lives; why we need a good flight recorder before anything crashes. *Endanger. Species Res.* 4: 123-137. (doi: 10.3354/esr00064 - 142 cites)

R2 Wilson, RP et al. (2006). Moving towards acceleration for estimates of activity-specific metabolic rate in free-living animals; the case of the cormorant. *J. Anim. Ecol.* 75: 1081-1090. (doi: 10.1111/j.1365-2656.2006.01127.x - 122 cites)

R3 Shepard ELC, **Wilson** RP et al. (2008) Identification of animal movement patterns using tri-axial accelerometry. *Endangered Species Research* 10: 47-60. (doi: 10.3354/esr0008 - 66 cites)

R4 Gleiss, A, **Wilson**, RP et al. (2011). Making dynamic body acceleration work: on the theory of acceleration as a proxy for energy expenditure. *Methods in Ecol. Evol.* 2: 23-33 (doi: 10.1111/j.2041-210X.2010.00057.x - 32 cites)

R5 Gleiss, AC et al. and **Wilson**, RP (2011). Convergent evolution in locomotory patterns of flying and swimming animals. *Nature Communications* 2: 352. (doi:10.1038/ncomms1350 - 15 cites)

R6 Wilson, RP et al. (2012). Construction of energy landscapes can clarify the movement and distribution of foraging animals. *Proc. Roy. Soc. B* 279: 975-980. (doi: 10.1098/rspb.2011.1544 10 cites, considered to be in the top 2% of published biology articles by the publisher Faculty of 1000 (F1000))

R1, R2 and R4 best represent the quality of the research.

4. Details of the impact

National Geographic's television producer [S1] became aware of the DD and approached Swansea University in 2008 regarding concepts for a proposed new series involving animal migrations. This individual became Senior Producer for *Great Migrations* and, in a letter to Swansea University (available on request) stated: "*This work was inspired by the finest scientists and scholars, including to a large part Professor Wilson's innovative work using smart tags to track a whole suite of animals and his invention of an animal-attached unit that he calls 'the Daily Diary'. This unique technology …. has revolutionized the study of animal movement and has made him a world leader in this field. Professor Wilson's expertise, technology and ability to communicate his findings was pivotal for the conceptualization and execution of our Series. Following initial contact with Professor Wilson during our development phase, he became our chief scientific advisor for the Series. He was intimately involved in the planning of the fieldwork, including species and site selection, and deployment of his tags on various species to inform the science (this latter being funded by National Geographic). His input was also critical for interpretation of the results obtained from the tags to bring new, exciting information on the science of animal movement to the general public*."

National Geographic's television programmes are science-driven and scientifically robust, based on the latest research and research techniques. The methodological advances conceived by Wilson were pivotal to the way in which National Geographic set out their concept for *Great Migrations* [S1] because the fine-scale properties of animal movement paths and their associated energetic costs were previously impossible to quantify despite being central for defining movement efficiency and thereby understanding patterns of migrating animals.

National Geographic provided funding [G2, G3] to enable Professor Wilson to use the DD on whales, seabirds, sharks and seals. This resulted in new discoveries about movement strategies in free-living animals and their ecological consequences [R5-6] which were included in the television series. Specifically, Professor Wilson featured in the episode *The Science of Migrations*, in which he explains the DD and its importance for understanding how animal movements relate to energetics (e.g. how penguins use positive buoyancy to catch prey from below, and the movements of elephant seals conducting drift dives).

Evidence of impact from the television series

Great Migrations was first presented in November 2010 as a seven-part series (of 1-hour episodes) showing animal migrations in different areas of the globe. This work, the highest budget in National Geographic's 124-year history, was eventually aired in 166 countries (in 34 different languages), accessible to 330 million people [S2]. There was a strong positive response to the series from both the press and the public:

The Press [S3]

The Guardian: "*The "Great Migrations" footage, which took three years to shoot, was filmed on land and from the air, in trees, cliff-blinds, ice floes and underwater across 420,000 miles and in 20 countries. … four core hours chronicle the stories of some of the planet's many animal species and their movements, thanks to new scientific discoveries about them and their natural history. ... This is a beautifully filmed, scripted and produced programme. ... I loved this programme*."

New York Times: "*National Geographic wants its own showcase of glossy, high-definition wildlife cinematography, whose success will be measured in marketing terms: sales of DVDs, books and overseas broadcast rights. In competitive terms, the main and perhaps the only question is, how does it look? Is the photography, done over the course of two and a half years in 20 countries (and involving 420,000 miles of human travel), sufficiently spectacular? … At moments, the answer is yes*."

Los Angeles Times: "*We can see the glorious and the brutal … (and) bring to them our own metaphors and meaning, and draw the inspiration that has moved so many to write, paint, chronicle and learn*."

More specialist coverage, such as '*Deep Sea News*' wrote '*They … paid homage to the decades of science that went into all the observations and behavior that were described. You almost need to see it through the lens of a science documentary, instead of a nature documentary. With that being said, I am sure it will remain one of the epic documentaries of our time*.'

The general public

Jason G. Goldman, a science writer who contributes to Scientific American, BBC Future, and Nautilus Magazine, explained how the *Great Migrations* impact is manifest; "*Documentary series like* Great Migrations *are important to science education and to nature conservancy, and in general they fulfil their function well. They inspire children and adults to care more for the world, and they leave us in awe of the biodiversity that surrounds us*."

National Geographic used the series to inform and educate the largest cross-platform initiative in its history, by releasing audio books, books aimed at adults and books for children. The children's books include '*Great Migrations; Whales, Wildebeests, Butterflies, Elephants, and Other Amazing Animals on the move'* and '*Amazing Journeys', 'Butterflies', 'Elephants'* and *'Whales'*. Xxx xxxxxx xxxx xxxxx xxx xxx xxxxx x xxxxxxx xxx xxx xxxx xxxx xx xxx xxxxxx xxxxxxxxxx. Xxx xxxxxxxxxxxxxxxxxxxx xxx xxx xxxxxx xxxxx xxx xxxx xxxxxx x xx xxx xxxx. In addition, 'Great Migrations' was the cover story and supplement in the November 2010 issue of the National Geographic Magazine and was featured in *National Geographic Traveller* and *National Geographic Kids* magazines. 'Great Migrations' was also the subject of a map, iPhone apps, downloadable games, a National Geographic Museum exhibit, *National Geographic Live* lecture series and screenings, education programmes, and several National Geographic Expeditions during which travellers could experience the wonders of migration first hand. As chief scientific advisor to the *Great Migrations* series, Professor Wilson was involved in red-carpet premiers of *Great Migrations* in New York, Los Angeles, Washington DC, Nairobi and several television and radio interviews across Europe and the United States, as well as in some of the National Geographic Expeditions.

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The Scientific Community [S5]
The value of this technology to biologists is manifest by its uptake by the commercial sector worldwide including for use on humans. A spin-out company from Swansea University (Wildbytes Technologies Ltd) was conceived to market the DD, and five companies now sell the tag (Customized Animal Tracking Solutions, Gulf Coast Data Concepts, Loggerhead Instruments, Wildlife Computers and Little Leonardo). Some of these companies [S5] refer specifically to Professor Wilson's contribution in their websites.

5. Sources to corroborate the impact

S1: The Senior Producer for *Great Migrations* can corroborate the importance of Wilson's work for the series (see also appended letter of support). The following URLs corroborate Professor Wilson's links with National Geographic:
http://www.ouramazingplanet.com/502-national-geographic-great-migrations-premiere.html
http://events.nationalgeographic.com/events/speakers-bureau/great-migrations/
http://events.nationalgeographic.com/events/speakers-bureau/speaker/rory-wilson/
(All retrieved November 2013)

S2: Nielsen Media Research provided 'Updated with final premiere viewing numbers' (this and other viewing figures available from Vice President, Communications and Talent Relations, National Geographic Channel) who can also corroborate data on sales of National Geographic products (not in the public domain).

S3: Examples of Press statements regarding *Great* Migrations are; http://www.theguardian.com/science/punctuated-equilibrium/2010/nov/04/2 Retrieved Jan 2013 http://www.nytimes.com/2010/11/06/arts/television/06migrations.html Retrieved Jan 2013 http://articles.latimes.com/2010/nov/05/entertainment/la-et-great-migrations-20101105 Retrieved Jan 2013 http://deepseanews.com/2010/11/great-migrations/ Retrieved March 2013

S4: *Great Migrations* education resources for school-age children are available at the National Geographic Education web portal created for teachers. See http://education.nationalgeographic.com/education/search/?csrfmiddlewaretoken=am9fnJHbuAM6ZttRSJIChkzsm6eWemXQ&token=great+migrations&searchSubmit.x=-1084&searchSubmit.y=-131&page_num=1&per_page=10&sorting=0&tab=0&ar_a=1&audiences=1#page_num=1&sorting=0&per_page=10&tab=0&token=great%20migrations Retrieved March 2013

This URL is an example of how National Geographic's facilitates the use of *Great Migrations* in education: http://education.nationalgeographic.co.uk/education/program/great-migrations-education-outreach/?ar_a=1 Retrieved March 2013

S5: The CEOs of 'Customized Animal Tracking Solutions', Australia and Wildlife Computers, USA can corroborate Professor Wilson's influence in their decision to produce and market DD tags. The Director of Wildbyte Technologies Ltd can confirm that the company was formed to bring the DD tag to market.