Institution: The Open University

Unit of Assessment: B7 Earth Systems and Environmental Sciences

Title of case study: Sharing ocean science with millions of people through the Blue Planet II TV series to stimulate public and political engagement with our oceans' health and influencing policy in the UK and Europe

Period when the underpinning research was undertaken: 2008-2018

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Philip Sexton	Senior Lecturer	2010 - present
Prof Mark Brandon MBE	Professor	2000 - present
Dr Miranda Dyson	Senior Lecturer	1995 - present
Dr Pallavi Anand	Senior Lecturer	2006 - present
Dr Carl Boardman	Lecturer	2009 - present

Period when the claimed impact occurred: 2017-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

The 2017 BBC TV series Blue Planet II was scientifically underpinned by Open University (OU) research on ocean processes, large-scale ocean circulation, marine carbon cycling and ocean acidification, geographic distributions of plankton, plastic degradability, and the courtship behaviour of marine animals. The OU staff's work had a significant impact by:

- Contributing to the production, and steering the series narrative and scientific content of, a landmark documentary series watched by >250 million people.
- Increasing awareness of, and changing public and political attitudes and behaviours towards, ocean health in the UK.
- Stimulating political debate and influencing policy in the UK and Europe.

2. Underpinning research

Large-scale ocean circulation

The Atlantic's Meridional Overturning Circulation (MOC) is a global conveyor belt of ocean currents that sustains life in the ocean through oxygen and nutrient-rich dense water sinking at the poles and being replaced by warm water from the tropics in a continuous circulation. As global warming melts icecaps this freshens and lowers the density of polar source waters that would otherwise sink and ventilate the deep ocean. The stratification of some oceans is increasing as they warm, creating natural barriers to the vertical transfer of oxygen and nutrients throughout our oceans.

Brandon's research has led to significant insights on the interaction between physical and biological processes in polar oceans that ventilate the ocean interior and drive the MOC **[O1]**. **Sexton** presented a new explanation for the compelling observation that tropical plankton disappeared from the Atlantic Ocean during each ice age and demonstrated that disappearances were driven by a better oxygenated tropical thermocline during ice ages. Water mass formation in relatively small polar areas thus regulates plankton population dynamics across the vast lower latitude oceans **[O2]**.

Marine carbon cycling and ocean acidification

The 'marine snow' of organic matter and shells of calcifying plankton that fall through the ocean when these organisms die acts as a 'biological pump' to transport carbon away from the upper ocean and atmosphere to the deep ocean **[O1, O3]** where it can remain for hundreds or thousands of years. This pump is a primary regulator of atmospheric CO_2 levels at these timescales. However, its complicated dynamics make it challenging to predict how climate change will affect this carbon pump. **Sexton** showed how carbon cycled within the ocean's interior impacted acidification and carbonate saturation during extreme global warming events analogous to our current situation, providing a deeper understanding of the ocean's likely response to ongoing global warming **[O2]**. **Anand** and **Sexton's** ongoing palaeoceanographic

proxy development programme yielded deeper understanding of the modern ocean's biological pump **[O3]**.

Geographic distributions of free-floating plankton and marine plastics

150 million tonnes of plastic reside in the world's oceans today, carried by the global ocean circulation. Endemic micro-plastics (<5 mm) are an increasing marine pollution component and interact detrimentally with species in a range of marine habitats.

Boardman has pioneered the use of remote sensing technology to detect micro-plastics and investigate the breakdown of plastic products in oceanic and terrestrial environments and has defined biodegradability standards for lightweight carrier bags **[O4]**. Coupled to **Sexton's** research that challenged the longstanding view that the ocean has tectonic and water mass 'barriers' to prevent the long-distance dispersal of free-floating plankton **[O5]**, we have new awareness of how and why microplastics are so widely dispersed.

Behavioural ecology of marine animals

Dyson's research on sensory physiology, mating systems, mate choice and courtship behaviour of frogs and fiddler crabs **[O6]** is pertinent to the marine animal behaviours addressed in Blue Planet II and has revealed new insights into the roles of intra- and inter-sexual selection in shaping animal mating systems and auditory and visual communication systems.

3. References to the research

O1. Weston, K., Jickells, T.D., Carson, D.S., Clarke, A., Meredith, M.P., **Brandon, M.A**., et al. (2013) Primary production export flux in Marguerite Bay (Antarctic Peninsula): Linking upper water-column production to sediment trap flux. *Deep Sea Research Part I: Oceanographic Research Papers*, 75, 52–66. https://doi.org/10.1016/j.dsr.2013.02.001

This paper analysed the sediment transport and carbon fluxes over two Antarctic winters beneath a winter sea ice cover. It was the first such analysis and allowed us to define how carbon cycles in productive polar systems and the role of ocean processes in the polar biological pump.Research supported by NERC grant NER/G/S/2002/00024 (GBP228,005).

O2. **Sexton, P.F**., Norris, R.D., Wilson, P.A., Pälike, H., Westerhold, T., Röhl, U., Bolton, C., and Gibbs, S. (2011) Eocene global warming events driven by ventilation of oceanic dissolved organic carbon, *Nature*, 471, 349-352. https://doi.org/10.1038/nature09826

Discovery of a previously unknown abundance of extreme, rapid carbon cycle perturbations within the Eocene 'greenhouse'. Contrary to the paradigm view, this work showed these events were driven by large-scale releases of carbon from the ocean. It also transformed understanding of ocean circulation and how carbon cycles within the ocean interior during warmer-than-modern climates. Research supported by **Sexton's** EU Marie Curie Outgoing International Fellowship 40177 (GBP238,686), **Sexton's** Leverhulme Trust Early Career Fellowship ECF/2009/0478 (GBP297,254), **Sexton's** competitive selection for participation in 2-month long Ocean Drilling Program (ODP) Leg 207, and UK Integrated Ocean Drilling Program (NERC) grant NE/I006443/1 (GBP46,636).

O3. Salmon, K.H., **Anand, P**., **Sexton, P.F**., and Conte, M. (2015) Upper ocean mixing controls the seasonality of planktonic foraminifer fluxes and associated strength of the carbonate pump in the oligotrophic North Atlantic, *Biogeosciences*, 12, 223-235. https://doi.org/10.5194/bg-12-223-2015

Through novel analyses of a unique, decades-long sediment trap series, this work showed how ocean circulation in the North Atlantic modulates the seasonality and strength of the biological carbonate pump and the implications of this for ocean chemistry. Research supported by **Anand** and Sexton's UK Ocean Acidification Research Programme (DEFRA-NERC-DECC) Tied PhD Studentship (GBP73,769).

O4. Harrison, J.P., **Boardman, C**., O'Callaghan, K., Delort, A-M., and Song, J. (2018) Biodegradability standards for carrier bags and plastic films in aquatic environments: a critical review. *Royal Society Open Science*, 5 (5) article no. 171792. https://doi.org/10.1098/rsos.171792

This work reviewed existing international industry standards for evaluating the biodegradability of plastics within aquatic environments and assessed the environmental fate of plastic carrier bags. It identified knowledge gaps and provided recommendations for developing new biodegradability standard(s) for lightweight plastic carrier bags. This paper was heavily used in a report that modified Government policy on biodegradable plastic bags. Research supported by Biodegradable Carrier Bag Feasibility Study (GBP244,740) and Aquapak Plastics Phase 2 (GBP47,148).

O5. **Sexton, P.F**., and Norris, R.D. (2008) Dispersal and biogeography of marine plankton: Long-distance dispersal of the foraminifer Truncorotalia truncatulinoides, *Geology*, 36(11), 899-902. https://doi.org/10.1130/G25232A.1

Tested for the operation of two competing hypotheses for the controls on plankton biogeography. Distinguished between them and found that, rather than the ocean possessing tectonic and water mass 'barriers' to plankton dispersal (a long-standing view), plankton are in fact able to freely disperse long distances, with implications for modes of speciation in plankton. It explained this high dispersal capability in the context of surface ocean circulation patterns and inter-ocean connectivity. Research supported by **Sexton's** EU Marie Curie Outgoing International Fellowship 40177 (GBP238,686).

O6. **Dyson, Miranda L**., and Backwell, Patricia R.Y. (2016) Alternative mating tactics and male mating success in two species of fiddler crab. Behaviour, 153(12) pp. 1403–1418. https://doi.org/10.1163/1568539X-00003386

This study provided a major advance in understanding how male mating tactics and female choice determine the evolution of sexual size dimorphism in animals.

4. Details of the impact

Shaping the scientific content of the BBC TV series Blue Planet II

The Open University (OU) was a co-producer of the BBC series. In 2014 **Sexton**, **Brandon**, **Dyson**, and **Anand** were appointed Scientific Advisors. Broadcast from October 2017, it explored global marine life and the associated environment **[C1]**. As co-producers our strategy involved advising on science and reaching publics directly through authoring associated material based on the series and our expertise. Approximately 37 million UK people and >500 million worldwide watched BPII **[C1]**. Our OU companion website had >661,000 unique visitors; 25,180 made study enquiries **[C2c]**. We authored and produced an A0 poster in English and Welsh with research-level scientific information exploring ocean functioning and health; it was requested and sent to >587,000 UK addresses and downloaded >100,000 times **[C2.1, C2.2, C2.3]**. Our interactive game/learning resource (*Ocean Explorer* >25,300 unique visitors) was a bridge to formal curriculum (>2,200 formal study enquiries) **[C2.4]**, approximately 12,500 people read **Dyson** and **Sexton's** BPII article in *The Conversation* **[C2.5]**.

We supported the Executive Producers and production team and informed the narrative, ensuring scientific accuracy **[C1]** – this was critical given the strong environmental messages. For example:

- Episode 2, The Deep articulated principals in **[O1 - O5]** on the biological pump and marine snow **[O1 - O3]**, deep water formation and circulation **[O1 - O5]**, controls on seawater density **[O1, O2]**, ventilation of the deep ocean and oxygen supply to the ocean interior **[O2, O3]**.
- Episode 3, Coral Reefs explored the impact of coral bleaching **[O2, O3]**.
- Episode 4, Big Blue drew on deep-ocean ventilation and large-scale ocean circulation research **[O2, O3, O5]** including a compelling animation of the overturning circulation system.
- Episodes 4, & 7, Our Blue Planet featured insights from **[O5]** on the distribution of free-floating plankton populations and the vertical overturning circulation **[O2, O3]** to contextualise oceanic plastics distribution; **[O4]** explained plastics dispersal.
- Episode 7 Contrasted the melting of floating ice shelves versus grounded ice on sea level rise **[O1]** and featured carbon chemistry insights on ocean acidification **[O2, O3]**.

Dyson's understanding of animal behaviour, communication, and physiology **[O6]** ensured all episodes reflected sound evolutionary knowledge.

Increasing awareness of, and changing public attitudes and behaviours towards ocean health

In 2018 the BBC and Open University co-produced *Blue Planet Live* – a three-week event – to highlight marine health. Boardman and **Dyson** were Scientific Advisors and, with **Sexton** and **Brandon**, produced a supporting booklet including information on plastics recycling sent to approximately 99,100 UK addresses on request **[C3.1]**; between March 2018 and October 2019, **Brandon** and **Sexton** held five 'oceans' talks to an audience of approximately 1371 across the UK and Ireland to share their own and OU colleagues' research **[O1-O6, C3.2]**.

Our survey sent to 467,502 poster recipients (89,188 responses – 19.1%) shows, after engaging with our poster: 94% said they better understood the threats facing our oceans, 91% felt motivated to change their behaviour to reduce their environmental impact (e.g., plastics use) and 48% have since enquired about climate change activism **[C6]**. Our survey of 139 OU talk attendees (42 responses – 30.2%) shows, because of attending: 93% reported increased awareness of ocean health, 91% changed their behaviour **[C6]**.

The public impact of BPII and associated public engagement activities catapulted ocean issues into public consciousness and this has changed people's attitudes and behaviour. An independent survey (n=2000) revealed similar findings to our own (n=89,188+139) – 88% of viewers having changed their behaviour regarding plastics as a result **[C5.1]**. Following broadcast, global conservation charities experienced major jumps in website traffic **[C5b]**. Independent research demonstrated an increase in plastic pollution-related terms being used by the media and politicians **[C4,** pp.7-13**]**. A letter from the UK Government Minister for Science, Research and Innovation confirmed the importance and impact of our work and approach on the global conversation **[C7]**.

Public consciousness stimulated political debate and influenced UK and European policy

Then Prime Minister Theresa May highlighted BPII in a speech on the environment **[C8.1]** and the series has been mentioned 140 times in parliamentary debates since broadcast 29/10/2017 **[C8.2]**: A November 2017 parliamentary debate on Antarctic ocean conservation policy described the series as "*an exemplar of the delicate and vulnerable nature of biodiversity in the deep oceans"* **[C8.3]**.

Blue Planet II influenced the UK Government to legislate to ban microbeads (2018), single-use plastics including straws (2020) **[C9]**, and to increase charges for single-use plastic bags in England from 5 to 10 pence (2018) **[C9]**. The European Commission cited BPII in its 2018 decision to ban single-use plastics **[C10]**.

5. Sources to corroborate the impact

C1. Testimonial from Senior Executive Producer of Blue Planet II stating our expertise impacted the programme content and the choices of production staff.

C2. BBC Blue Planet companion website evidence:
C2.1 Blue Planet companion Open Learn website.
C2.2 Blue Planet Oceans poster.
C2.3 Blue Planet companion Open Learn website analytics and evidence of enquiries for Open University study as a direct result of accessing Open Learn materials & Evidence of requests for poster.
C2.4 Evidence of Ocean Explorer unique users and the number of those who subsequently enquired about studying with The Open University.
C2.5 Article in The Conversation, 27th October 2017.

C3. Blue Planet Live evidence:
C3.1 Companion booklet.
C3.2 Audio visual presentation and audience question and answer sessions by Professor Mark **Brandon** and Dr Phil **Sexton** called *The Science behind the BBC Series Blue Planet*

II.
Talk presented at the National Museum of Wales Cardiff. 28 Mar 2018. Audience: approximately 200.
Talk presented at Coleg Cambria Deeside Sixth Form College 30 Jan 2019 Afternoon to staff and students): Audience 32. Talk presented at Coleg Cambria Deeside Sixth Form College 30 Jan 2019 evening.
Talk simultaneously translated into Welsh and broadcast bilingual on Facebook. Audience: approximately 140. Audience on Facebook: 499.
Talk presented at The Royal Irish Academy, 19 Dawson Street, Dublin: 13 February 2019: Audience: approximately 100.
Talk presented at the BBC Blackstaff Studios, Belfast at the Northern Ireland Science Festival. 14 February 2019: Audience: approximately 150.
Talk presented at the Dynamic Earth Edinburgh. 14 October 2019: Audience: approximately 250.
Total audience in person approximately 872, Audience online 499.

C4. Males, J. and Van Aelst, P., 2020. Did the Blue Planet set the Agenda for Plastic Pollution? An Explorative Study on the Influence of a Documentary on the Public, Media and Political Agendas. *Environmental Communication*, pp.1-15. DOI: 10.1080/17524032.2020.1780458.

C5. Independent research/surveys:
C5.1 Waitrose & Partners Food and Drink Report 2018. Surveys respondents no: 2,000.
C5.2 The Attenborough effect: Searches for plastic recycling rocket after Blue Planet II, Resource.co, 5th January 2018.

C6. Results of October/November 2020 questionnaires of 139 OU-sponsored talk attendees and 467,502 poster recipients.

C7. Personal letter from an MP, Minister for Science, Research & Innovation, 12 January 2021 to Mark **Brandon** confirming our work has "*deliver[ed] a dramatic wake up call to the world*".

C8. Evidence of Blue Planet II influence in UK parliamentary discussions since October 2017:
C8.1 Prime Minister's speech on the environment "*The problem was vividly highlighted in the BBC's recent Blue Planet II series, which was public service broadcasting at its finest*". 11th January 2018.
C8.2 House of Commons Hansard Reports: (a) Antarctica; (b) Blue Belt Programme: Marine Protected Areas; (c) Hansard Search: Blue Planet, 18th December 2020.
C8.3 Marine Environment discussion in parliament, 3pm, 14th November 2020.

C9. Influencing UK governmental policies relating to plastics pollution:
C9.1 Environment Secretary Michael Gove vowing to take action over plastic pollution in the oceans after being "*haunted*" by watching Blue Planet II, Twitter, 20th November 2017.
C9.2 Michael Gove's measures aimed at curbing plastic consumption: 5p charge for plastic bags being increased to 10p [27th Dec 2018].
C9.3 The UK government going further and vowing in Jan 2018 to ban single-use plastics with specific reference to Blue Planet II, Twitter, Theresa May, 7th January 2018
C9.4 The microbead ban [9th Jan 2018].
C9.5 Press release: UK Government rallies Commonwealth to unite on marine waste.

C10. Influencing European Commission policies relating to plastics pollution:
C10.1 Vice-president of the European Commission, Frans Timmermans commenting about the impact that Blue Planet on the public opinion in the United Kingdom, 16th January 2018.
C10.2 The EU announcing a proposal for a complete ban on single-use plastics across the EU, 28th May 2018.
C10.3 The European Parliament voted for their complete ban, 24th Oct 2018.