

<b>Institution:</b> University of Oxford		
<b>Unit of Assessment:</b> 5 – Biological Sciences		
<b>Title of case study:</b> New marine protection areas and protected species designation to advance seabird conservation		
<b>Period when the underpinning research was undertaken:</b> 2006 - 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>
Tim Guilford	Professor of Animal Behaviour	1997 - present
Tom Hart	Research Fellow	2010 - present
Dora Biro	Postdoctoral Researcher, later Royal Society URF, then Associate Professor	2003 - present
<b>Period when the claimed impact occurred:</b> Aug 2013 - December 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<p><b>1. Summary of the impact</b></p> <p>Conservation of the oceans is a global priority, covered by UN Sustainable Development Goal 14. Seabirds play a key role in marine ecosystems and are important indicators of ocean health, as well as being amongst the most threatened and fastest declining taxa on Earth. Behavioural ecological studies undertaken by seabird monitoring projects at the University of Oxford have been used to inform species and area protection at national and international level. Research provided evidence for the designation of one new marine Special Protection Area (Irish Sea), one new Marine Protected Area (South Georgia and South Sandwich Islands) and the proposed designation of one of the largest high-seas Marine Protected Areas in the northern hemisphere (Evlanov Seamount). The research has also supported the designation of Europe's most threatened endemic seabird species, the Balearic shearwater <i>Puffinus mauretanicus</i>, as Critically Endangered and Priority Populations by conservation global authorities. This has enabled the UK to meet obligations set out in the EU Birds Directive (2009/147/EC), and contributed to targets on conserving marine areas set by the UN.</p> <p>The Oxford research has also engaged new publics with conservation via the citizen science projects Penguin Watch and Seabird Watch. Over 1,000,000 people have participated and evaluation demonstrate the value of engagement, for example 87% of teachers surveyed said they had modified their curriculum as a result of Penguin Watch.</p>		
<p><b>2. Underpinning research</b></p> <p>The underpinning research falls into two methods that have been pioneered by University of Oxford zoology researchers and scaled up to influence practitioners: tracking with machine learning and image analysis combining citizen science and machine learning. Work by Prof Tim Guilford and Prof Dora Biro trialled and developed technology for tracking behaviour and movement in flying birds; this was then first applied to pelagic seabirds in 2006 [1]. Professor Guilford's group has since pioneered the development and application of machine learning approaches to tracking data analysis to combine biotelemetric data with field-based life-history measurements ('ethoinformatics').</p> <p>Multi-colony tracking of breeding Manx shearwaters (<i>Puffinus puffinus</i>) across years (including on National Nature Reserves Skomer and Rum), starting in 2008 and still ongoing, led to the first reliable spatio-temporal quantification of foraging areas for known breeding stage and provenance birds in UK waters (e.g. [2]). This research was developed by Guilford's group, who were instrumental in pioneering the tracking technology application for small seabirds, and the hi-tech field study systems used (on the islands of Skomer, Skoholm, Ramsey, Lundy, Copeland, and Rum in the UK, Nolsoy in the Faroes, and Mallorca, Menorca, and Sa Dragonera in the Balearics). Ethoinformatic analysis (pioneered by the group, with input from researchers in Oxford's Department of Engineering Science) allowed the recognition of at-sea behaviours remotely from</p>		

tracking data for the first time in seabirds [1, 2], contributing to the identification of behaviourally important ocean hotspots for North Atlantic pelagic seabirds and focussed recommendations for marine conservation areas and policies.

Europe's rarest endemic seabird, the Balearic shearwater (*Puffinus mauretanicus*), was poorly understood because of its rarity and elusive breeding habits in caves and remote cliff habitats. Tracking research has revealed both the consistent foraging behaviour patterns of breeding birds in the Mediterranean using GPS/TDR and Accelerometers and in the NE Atlantic during the non-breeding migration period using GLS/Immersion loggers [3]. Oxford monitoring data have contributed to recent demographic modelling with Spanish collaborators indicating a 14% annual population decline; the major cause being by-catch in fishing gear. Tracking and stable isotope studies have corroborated the evidence of by-catch risk.

Penguin Watch, a research programme in the Scotia Arc region of Antarctica and an online citizen science project, established a network of time-lapse cameras overlooking seabird colonies. Cameras are deployed to monitor penguins year-round, including monitoring phenology (i.e. timing of breeding) [4] and reproductive success [5], so as to better understand how threats to the ecosystem disrupt the dynamics of resident wildlife at a large scale. This approach has resulted in an integrated monitoring network of 'virtual ecologists' that has the capacity to provide near real-time data to policy-makers on hard-to-reach areas particularly sensitive to fishing, climate change and other human disturbances. Citizen Science on the Oxford-led Zooniverse platform has allowed researchers to rapidly annotate and process data at a scale that would be impossible for a small team of research experts.

Researchers have combined citizen science with computer vision, again in collaboration with the Department of Engineering Science at Oxford. The resulting recognition tool, by which computers can automatically count every individual in an image [4], is able to provide novel research data, to highlight unusual events (which are passed to citizen science to allow human interpretation) and to provide evidence for better conservation planning [6].

### 3. References to the research

(University of Oxford UOA5 staff in bold and University of Oxford students in italics)

1. **Guilford T**, *Meade J, Freeman R, Biro D, Evans T*, Bonadonna F, Boyle D, Roberts S and Perrins CM. (2008). GPS tracking of the foraging movements of Manx Shearwaters *Puffinus puffinus* breeding on Skomer Island, Wales. *Ibis*, 150:462-473  
DOI: [10.1111/j.1474-919X.2008.00805.x](https://doi.org/10.1111/j.1474-919X.2008.00805.x)
2. *Dean B, Freeman R, Kirk H, Leonard K, Phillips RA, Perrins CM & Guilford T*. (2013) Behavioural mapping of a pelagic seabird: combining multiple sensors and hidden Markov models reveals at-sea behaviour and key foraging areas. *J. R. Soc. Interface*. 10: 20120570  
DOI: [10.1098/rsif.2012.0570](https://doi.org/10.1098/rsif.2012.0570)
3. **Guilford T**, Wynn R, McMinn M, Rodriguez A, *Fayet A, Maurice L, Jones A & Meier R* (2012) Geolocators reveal migration and pre-breeding behaviour of the critically endangered Balearic shearwater *Puffinus mauretanicus*. *PLoS ONE* 7(3): e33753  
DOI: [10.1371/journal.pone.0033753](https://doi.org/10.1371/journal.pone.0033753)
4. *Jones FM, Allen C, Arteta C, Arthur J, Black C, Emmerson LM, Freeman R, Hines G, Lintott CJ, Macháčková Z, Miller G, Simpson R, Southwell C, Torsley HR, Zisserman A and Hart T* (2018). Time-lapse imagery and volunteer classifications from the Zooniverse Penguin Watch project. *Sci Data* 5, 180124 (2018). DOI: [10.1038/sdata.2018.124](https://doi.org/10.1038/sdata.2018.124)
5. Youngflesh C, *Jones FM, Lynch HJ, Arthur J, Macháčková Z, Torsley HR & Hart T*. (2020) Large-scale assessment of intra- and inter-annual nesting success using a remote camera network, *RSEC* 7(1) 97-108. DOI: [10.1002/rse.2.171](https://doi.org/10.1002/rse.2.171)
6. **Hart T** & Convey P (2018). The South Sandwich Islands – a terrestrial community of metapopulations across all trophic levels. *Biodiversity* 19 (1-2), 20-33  
DOI: [10.1080/14888386.2018.1464952](https://doi.org/10.1080/14888386.2018.1464952)

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#### 4. Details of the impact

Conservation of the oceans is a global priority, not just in terms of the preservation of marine biodiversity, but because of the central role that oceans play in the regulation of almost all the systems that make life on Earth possible. This is recognised in UN Sustainable Development Goal (SDG) 14 “Life Below Water”, which states that “*Careful management of this essential global resource is a key feature of a sustainable future... Marine biodiversity is critical to the health of people and our planet*” and notes that “*over three billion people depend on marine and coastal biodiversity for their livelihoods.*”

Pelagic seabirds (those that spend most of their time on or in the open ocean) play a key role in marine ecosystems. As higher predators, seabirds such as those studied at Oxford are sentinel species that provide an early warning of large-scale environmental disturbance. Monitoring and tracking seabirds has been shown to provide an accurate alert of threats such as overfishing and pollution. Pelagic seabirds are amongst the most threatened and fastest declining taxa on Earth and their conservation is a priority, covered by the Convention on Migratory Species.

#### Public policy – protected areas and changes in conservation listings

To help achieve SDG14, the UN set a target of conserving at least 10% of coastal and marine areas worldwide by 2020. The purpose of SPAs and MPAs is to stop or limit fishing and other harmful activities in areas that are important for species and habitats, thereby helping to increase the resilience of marine environments to stressors outside these areas. SPAs are special sites designated under the EU Birds Directive (2009/147/EC) to protect rare, vulnerable and migratory birds. The Oxford research provided key scientific evidence for the creation and enhancements of several important protected areas in the UK, UK Overseas Territories and in international waters, thus helping to meet the targets of UN SDG14.

In 2016, the UK Government’s Joint Nature Conservation Committee (JNCC) designated a 180km<sup>2</sup> area of the Irish Sea as a new marine SPA (the Irish Sea Front SPA). The research on Manx shearwater foraging behaviour [1, 2] demonstrated the importance of this intensively-used sea area as a foraging hotspot for nearly 400,000 breeding shearwaters from all the major UK colonies situated up to 320km away. This was one of the central pieces of evidence used to support the creation of the SPA [A], which has also enabled the UK Government to meet obligations set in the EU Birds Directive. The Directive provides a framework for the conservation of wild birds in Europe. Further tracking research has contributed to consultation stages of other UK MPA processes, including extensions to the Welsh SPAs with marine components.

At-sea distribution data from the tracking of migratory and foraging seabirds formed a core component of a proposal led by BirdLife International for an OSPAR High Seas MPA (North Atlantic Current and Evlanov Seamount). OSPAR is the mechanism by which 15 governments and the EU cooperate to protect the marine environment of the North-East Atlantic. The Oxford research helped BirdLife International to argue the case for this MPA, since it showed that the proposed area was intensively used as a stopover by shearwaters during their long distance migration between the breeding areas in the North Atlantic and non-breeding areas in the South Atlantic and Oxford research is referenced throughout the nomination [B]. The High Seas MPA is one of the largest ever marine protected area proposals at around 650,000km<sup>2</sup>, and has now been provisionally accepted under the Oslo-Paris agreement.

University of Oxford research data [4, 6] have provided scientific evidence for MPA designation [C] around South Georgia and the South Sandwich Islands. A review of known trends and threats coupled with the population structure of penguins in the South Sandwich Islands was presented as evidence to the Government of South Georgia (GSGSSI), and this influenced the design of an increased fisheries’ no-take zone around the South Sandwich Islands. The Oxford research highlighted where (currently unfished) quota of krill would impact penguins on the Antarctic Peninsula if this quota were released. The MPA followed these guidelines of the foraging areas of penguins and ensured the protection of key penguin populations, while also reducing the risk that fishing effort would be displaced to the Antarctic Peninsula.

The Director of Fisheries and Environment, Government of South Georgia, confirms: “*On the basis of the evidence provided..., GSGSSI considered [Dr Hart’s] recommendation to extend the ‘No Take Zone’ (NTZ) around the South Sandwich islands. This advice included extending the NTZ*

*from 3km out to 50km in order to reduce the potential for competition for food resources between the region's krill fisheries and penguin populations. The rationale behind the extension was to encompass the foraging range of the penguin species in the region as determined by Dr Hart and colleagues' recent research... This entered into GSGSSI legislation in May 2019."* [D].

Oxford research has also contributed to important changes in conservation status and protection for the Balearic shearwater, Europe's rarest seabird, which has a world population of 25,000 to 30,000. It breeds in the Mediterranean and migrates north into the Atlantic in the summer, with as many as 25% of birds spending time in UK waters. The species is predicted to be heading for extinction; entanglement in fishing nets is a major cause of death. In 2016, Guilford and others helped drive the designation of the Balearic shearwater becoming an ACAP (Agreement on the Conservation of Albatrosses and Petrels) Priority Population (one of eight worldwide), supporting global efforts to promote the recognition and conservation of this species [E]. SEO/Birdlife confirm the role Oxford research played in *"providing assessment to ACAP [...] to propose the species as a priority population for the Agreement, which was accepted by the Advisory Committee (Guilford & Arcos 2016). This has facilitated funding research and conservation action on the species afterwards, including ACAP grants as well as other sources of funding."* [F].

Since 2004 the Balearic shearwater has been designated a Critically Endangered species in the IUCN's Red List, as it is in rapid decline. In the 2018 revision of the Red List, the Oxford research formed part of the evidence used to keep the species at Critically Endangered. However, following this there was a move to reduce its status to Near Threatened, much lower on IUCN's scale of concern. In April 2020 the Oxford research [3] played a significant part in preventing this reduction in status [G]. The letter from SEO/Birdlife further describes the researcher's *"contribution to the Red List Forum of BirdLife International/IUCN to review the conservation status of the Balearic Shearwater, providing information that helped to keep the species as Critically Endangered."* [F]

In addition, the Oxford group was involved in providing evidence that night setting of fishing activity (mainly longlining) would be effective for mitigating by-catch of shearwaters. This measure is now incorporated into Birdlife International recommendations [H]. In the UK, the Oxford group has provided expert scientific advice to the Balearic Shearwater Working Group which works to understand the distribution, abundance and conservation requirements of the UK's only globally Critically Endangered bird species. Natural England's Principal Advisor states that the Oxford research has given them a basis on which to plan for better UK conservation of this species, describing it as *'a crucial step for conservation of this species in the UK'* and *'a major advance in the evidence required to safeguard the future of a Critically Endangered species'* [I].

### **Impacts on understanding, learning and participation through citizen science**

In September 2014 Penguin Watch was established as a citizen science project on the Oxford-led Zooniverse platform [4, 5]. Volunteers were asked to count penguins in images and time-lapse footage captured by satellites and drones. More than 1,000,000 people have taken part over two iterations of Penguin Watch without registering, and there are currently 21,894 registered volunteers who visit repeatedly. Version 1 from April 2014 to June 2017 had 54,000 registered volunteers. In a survey of volunteers, conducted in December 2020, 97% of 513 respondents said they would suggest Penguin Watch to others [J].

Penguin Watch has regular outreach in schools and was the featured citizen project of British Science Week 2017 (BSW), with 21,650 downloads of the primary school pack and 8,770 of the secondary school pack. Over 150 schools followed up directly with a request for more data and videos. Many people asked additional questions on the project's "talk" forum. The participation counter for the BSW challenge recorded 521,678 images classified, exceeding the target of 250,000 images. During the Covid-19 pandemic there has been a huge uptick in interest from schools, with 385,010 images analysed in April 2020, ten times as many as in April 2018 (31,246 images) and April 2019 (30,324) [K].

The education part of the Penguin Watch site has presentations, videos and data available for download. This has been very popular during 2020, as teachers have used it for online teaching, and Duke of Edinburgh Award candidates have used Penguin Watch as their volunteering component. Of 16 volunteers who identified as teachers, 87% said they had modified their curriculum, for example on climate change, because of Penguin Watch. 93% of teachers described the level of engagement of their students as Excellent or Good when volunteering for



Penguin Watch [J]. One testimonial from a US high school biology teacher described: *“The first time I incorporated PenguinWatch into my classes I quickly realized no one teaches about Antarctica.... I quickly began learning everything I could, I was not taught about Antarctica in school either. We learned geography, the location of bases, where Dr. Hart’s research was focused, and about several penguin species. The students were fascinated and so was I.”* [L]

Some volunteers have become extremely engaged, using Penguin Watch data as training workshops or degree level projects. Three of the project’s most enthusiastic volunteers have used Penguin Watch to develop skills in biology research and academic writing skills, to the point of contributing data and content to a study [5].

### Impacts on non-academic practitioners and government agencies

Penguin Watch has seeded a number of camera-based remote studies on seabirds and other taxa. At the Seabird Conference in Liverpool in September 2018, training was given to new non-academic partners from the British Indian Ocean Territory, Ascension, Turks and Caicos and Anguilla. The project has also continued to help St Helena Environment Department, and Falklands Conservation, Chile, New Zealand and Australia. Around the UK cameras previously used in Antarctica were donated to Jersey, Orkney and Isles of Scilly, and Penguin Watch has helped Birdlife and the RSPB to establish monitoring sites on the UK mainland at Bempton Cliffs, the Isle of May, Skomer Island, Ramsey Island and Natural England on Brownsea Island. Natural England’s Principal Advisor confirmed, *“This information is crucial to understand management requirements of recently designated Marine Protected Areas so that these rare and highly protected birds can breed successfully. The cameras worked well and given movement restrictions during the Covid 19 pandemic, they have helped a lot to fill gaps in our monitoring. Natural England is now an enthusiastic proponent of camera monitoring as part of the UK & Ireland Seabird Monitoring Programme.”* [I].

Penguin Watch has served as a case-study and model for many other wildlife monitoring projects that have been initiated, many also on the Zooniverse platform. For example, it has helped international government scientists from the US National Oceanic and Atmospheric Administration to build ‘Seal Watch’ and Parks Canada to build the ‘Arctic Bears’ project.

### 5. Sources to corroborate the impact

- A. The Joint Nature Conservation Committee’s webpage on the Irish Sea Front marine SPA (published April 2019) <https://jncc.gov.uk/our-work/irish-sea-front-spa/>
- B. OSPAR nomination for a “North Atlantic Current and Evlanov Seamount” MPA (2019) [https://www.ospar.org/site/assets/files/38964/ospar\\_naces\\_mpa\\_nomination\\_proforma\\_with\\_annexes\\_version\\_for\\_views.pdf](https://www.ospar.org/site/assets/files/38964/ospar_naces_mpa_nomination_proforma_with_annexes_version_for_views.pdf)
- C. The South Georgia and South Sandwich Islands MPA Review (November 2018) [http://www.gov.gs/docsarchive/Environment/Marine%20Protected%20Area/SGSSI\\_5year\\_MPA\\_Review\\_Summary\\_Report\\_to\\_GSGSSI\\_\(Nov%202018\).pdf](http://www.gov.gs/docsarchive/Environment/Marine%20Protected%20Area/SGSSI_5year_MPA_Review_Summary_Report_to_GSGSSI_(Nov%202018).pdf)
- D. Letter from the Director of Fisheries and Environment, South Georgia Government
- E. ACAP Priority Population Assessment for the Balearic shearwater, Population and Conservation Status WG Meeting 3, April 2016. Accessed via Working Documents at <https://www.acap.aq/working-groups/population-and-conservation-status-working-group/population-and-conservation-status-wg-meeting-3>
- F. Letter from Marine Programme Co-ordinator of SEO/BirdLife
- G. The IUCN Red List of Threatened Species 2018. Citation: *Puffinus mauretanicus*. <https://www.iucnredlist.org/species/22728432/132658315>
- H. Birdlife species factsheet for Balearic Shearwater <http://datazone.birdlife.org/species/factsheet/balearic-shearwater-puffinus-mauretanicus/text>
- I. Letter from the Principal Advisor, Natural England, 29-10-2020
- J. Report of Penguin Watch surveys of citizen science volunteers, December 2020
- K. Penguin Watch classification statistics 2018-2020, available via <https://www.zooniverse.org/projects/penguintom79/penguin-watch/stats/>
- L. Testimonial e-mail from US high school biology teacher, 24-12-2020