

Institution: University of Cumbria (UoC)		
Unit of Assessment: UOA14: Geography and Environmental Studies		
Title of case study: Conserving marine mammals and their habitat through better understanding of their behaviour and the effect of noise pollution		
Period when the underpinning research was undertaken: 2014-2017		
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:
Volker Deecke	Associate Professor	2012-Present
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>Through Associate Professor Volker Deecke, the University of Cumbria is involved in national and international collaborative research on the behaviour, ecology, and communication of marine mammals, particularly focused on resolving conservation issues related to the effect of underwater noise on marine mammal behaviour. This research has influenced government policy by informing endangered species legislation and guidance in Canada, Iceland, the USA, and the UK. The research has also influenced stakeholder behaviour by informing best practice regarding marine mammal research and raising public awareness.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>Deecke has been a lead researcher and collaborator on studies into the acoustic communication, cognition and feeding behaviour of marine mammals and the impact of underwater noise on these processes for over two decades. One main research focus has been on the underwater communication, population structure and foraging behaviour of killer whales (<i>Orcinus orca</i>) in the Northeast Pacific (British Columbia, Canada; Alaska and Washington State, USA) and Northeast Atlantic (Shetland, UK, and Iceland).</p> <p>The research in the Northeast Pacific (R1, R2, and R6) has provided insights into the acoustic communication and foraging behaviour relevant to identifying critical feeding habitat of endangered and threatened coastal killer whale populations in Canadian and US waters. This has involved the use of innovative recording tags attached to the animals temporarily with suction cups to pinpoint the location of feeding events and thus identify critical feeding habitat (R6). R6 has additionally provided findings about killer whale behavioural responses to shipping noise which has influenced research and policy to mitigate the effects of marine traffic on killer whale feeding behaviour and access to feeding habitat.</p> <p>In the Northeast Atlantic, Deecke's acoustic research off Shetland was the first to establish an acoustic link between herring-feeding killer whales in Icelandic and UK waters. Herring-eating killer whales in these waters produce a distinctive call type, thought to affect the schooling behaviour of herring, which had previously only been recorded off Iceland. Further acoustic research and photographic identification (R4, R5) has since followed up the connection, which confirmed that individuals regularly travel between both regions. R4 and R5 have therefore helped to establish the identity of killer whale populations, and to determine population sizes and ranges. These findings are crucial for effective management and conservation of Northeast Atlantic killer whales in both UK and Icelandic waters.</p> <p>In addition, Deecke has held a leading role in designing and conducting research into the impact of anthropogenic noise on marine mammal behaviour. While many marine species are adversely affected by noise pollution, some are able to extract useful information from it that can help in underwater orientation, or finding food and mates. R3 showed that captive grey seals, <i>Halichoerus grypus</i>, will spontaneously learn to associate acoustic tags used to track fish at sea with a food reward. Such tags are used extensively to study movement patterns and mortality of a variety of fish species at sea, including endangered fish stocks such as Pacific salmon (<i>Oncorhynchus</i> spp.). The 'dinner-bell effect' demonstrated by R3 has considerable ethical and practical implications on the use of such tags and the validity of the resulting data in management and conservation. These findings are increasingly being used to develop regulatory guidelines regarding the use of acoustic tags on fish.</p>		

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

- R1. Deecke, V.B., Ford, J.K.B., Spong, P. (2000). Dialect change in resident killer whales: implications for vocal learning and cultural transmission. *Animal Behaviour*, 60, 629-638. doi.org/10.1006/anbe.2000.1454.
- R2. Riesch, R., Barrett-Lennard, L. G., Ellis, G. M., Ford, J. K. B. & Deecke, V. B. (2012). Cultural traditions and the evolution of reproductive isolation: Ecological speciation in killer whales? *Biological Journal of the Linnean Society*, 106, 1–17. doi.org/10.1111/j.1095-8312.2012.01872.x.
- R3. Stansbury, A. L., Götz, T., Deecke, V. B. & Janik, V. M. (2015). Grey seals use anthropogenic signals from acoustic tags to locate fish: evidence from a simulated foraging task. *Proceedings of the Royal Society of London B: Biological Sciences*, 282, 20141595. doi.org/10.1098/rspb.2014.1595.
- R4. Samarra, F. I. P., Deecke, V. B. & Miller, P. J. O. (2016). Low-frequency signals produced by Northeast Atlantic killer whales (*Orcinus orca*). *Journal of the Acoustical Society of America*, 139, 1149-1157. doi.org/10.1121/1.4943555.
- R5. Samarra, F. I. P., Tavares, S. B., Béésau, J., Deecke, V. B., Fennell, A., Miller, P. J. O., Pétursson, H., Sigurjónsson, J. & Víkingsson, G. A. (2017). Movements and site fidelity of killer whales (*Orcinus orca*) relative to seasonal and long-term shifts in herring (*Clupea harengus*) distribution. *Marine Biology*, 164, 159. doi.org/10.1007/s00227-017-3187-9.
- R6. Wright, B. M., Ford, J. K. B., Ellis, G. M., Deecke, V. B., Shapiro, A. D., Battaile, B. C. & Trites, A. W. (2017). Fine-scale foraging movements by fish-eating killer whales (*Orcinus orca*) relate to the vertical distributions and escape responses of salmonid prey (*Oncorhynchus* spp.). *Movement Ecology*, 5, e3. doi.org/10.1186/s40462-017-0094-0.

All of these papers have been published in peer-reviewed research journals. R3 has been hailed as one of the must-read papers in aquatic and fisheries science and was showcased in the Research Highlights section of the journal Nature on 26 November 2014.

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

Context: This case study is underpinned by research on killer whale (KW) population structure and behaviour and the effect of anthropogenic sounds on marine mammals (killer whales and grey seals). The research has influenced government policy and guidance internationally and contributed to public understanding through popular literature.

Killer whales (KW) attract considerable public attention and are a familiar sight, both in captivity at marine parks, and in the wild, with ecotourism related to KW's being valuable to regional economies in western Canada, the USA, Iceland, and the Northern Isles of Scotland. Despite this socio-economic importance, determining global conservation status continues to be a challenge. Habitat requirements remain difficult to understand, limiting ability to identify and protect critical habitat. KW's have an IUCN categorisation of 'data-deficient', meaning that there is insufficient information to make a proper assessment of conservation status. However, some nations have chosen to take legislative action. This includes protecting the Southern Resident KW population, off British Columbia and Washington State, which is included on the US Endangered Species List, and has 'endangered' status according to Canada's Species at Risk Act (Schedule 1: List of Wildlife Species at Risk). The Northern Resident population (found off northern Vancouver Island, and along British Columbia's Central and North coasts) are listed as 'threatened' on Canada's Schedule 1.

Main threats to KW's include pollution, decreased prey availability, and negative effects of vessel traffic and underwater sound. Northern and Southern Residents exclusively feed on fish, especially salmonids, and are significantly affected by salmon abundance. High levels of noise have been demonstrated to cause animals to abandon critical feeding habitat, whilst vessel noise also reduces the distance over which calls are audible and decreases the functional range of echolocation to detect prey. The research has therefore sought to examine effects of the complex interaction between decreasing prey and increasing noise, prompting mitigative and preventive measures for both KW populations.

Impact 1: Influencing the Canadian government to establish new KW protected areas

Deecke is a member of the Recovery Team for West Coast Transient Killer Whales (since 2003), advising the Canadian Government on implementing policy. This has resulted in the research influencing a number of agencies to take action, including the Canadian Science Advisory Secretariat (CSAS). CSAS coordinate scientific peer review and advice for Fisheries and Oceans Canada (DFO), the federal lead for managing Canada's marine and freshwater resources and biodiversity. Due to their conservation status in Canada, CSAS is obligated to identify new critical habitat for the Northern and Southern KW populations, and their 2017 'Research Document 2017/035' proposed two new areas for national designation as 'critical habitat' (S1) – the waters on the continental shelf off south-western Vancouver Island and of west Dixon Entrance. The CSAS report utilises R1, R2 & R6 on the acoustic communication and foraging behaviour of resident KW's to identify these two new areas for protection (S1, p.p. 3, 26, 30, and 31). This represents important *"year-round habitat for Resident Killer Whales, especially for feeding on the whales' primary prey, Chinook Salmon"* (S1, p. vii.).

As a result of the Research Document, DFO announced the designation of these two new areas as critical habitat for resident KW's off the British Columbia coast in 2018. This increased the area of critical habitat for endangered KW's in Canadian waters by (approximately) 6,419km² to an area of 10,714 km² (S2). Designation ensures that this critical habitat is legally protected against development and industrial activity that could hinder whale survival or recovery, and our research has contributed to this protected area enlargement.

Impact 2: Working with the Port of Vancouver to implement conservation actions

Research on the foraging behaviour of resident KW populations (R6) demonstrated that the species is negatively impacted by noise pollution. As a result of this research, Deecke was invited to contribute to the Vancouver Fraser Port Authority's 'Enhancing Cetacean Habitat and Observation (ECHO) Program' via ecological consultancy, SMRU Consulting Ltd., who are members of ECHO's Acoustic Technical Committee (S3). To access the Port of Vancouver, commercial vessels must transit areas of DFO-designated 'critical habitat' for southern resident KW's, and ECHO was established in 2014 to protect the resident cetacean species and this important habitat.

Drawing on R6, Deecke's work on Northern Resident KW's was used by SMRU to identify possible actions as part of ECHO, resulting in the design of an experimental trial in 2017 to decrease the speed of super-tankers and large cargo vessels accessing the Port (S3). Acoustic noise from shipping vessels confuses and interferes with the acoustic signals emitted by toothed whales to locate food, and a trial reduction of vessel speed while transiting critical habitat was designed to decrease underwater noise and negative impact on endangered Southern Resident KW's. From the trial data, a simulation was constructed which indicated that despite only 44% of 'transits' achieving the target slowdown speed of 11 knots, the 'potential lost foraging time' for the killer whale population was reduced by 22%. If 100% of transits adhered to this limit, the reduction would be 40%.

Following the success of the Port's first voluntary vessel slowdown trial, the exercise was repeated in July through October 2018, and again in 2019, when an expanded geographic area almost doubled the slowdown distance. The port authority also entered into a first-of-its-kind Species at Risk Act, Section 11 conservation agreement with eight other partners in 2019, with a goal to *"to reduce the acoustic and physical disturbance to SRKW [southern resident killer whales] by large commercial vessels in Pacific Canadian waters...through the continuation of existing voluntary efforts and the commitment to develop and implement new voluntary threat reduction measures to support the recovery of the SRKW"* (S4).

Our research enabled the benefits of the slowdown (for KW's) to be easily communicated to stakeholders and port users, ensuring action is being taken to reduce acoustic interference for cetaceans in this area. For the first time, there is now an economic incentive to make ships quieter. Commercial ports setting restrictions on noise outputs by vessels permitted to use them incentivises shipping companies to purchase quieter ships and to marine engineering companies to build them. This will ultimately benefit marine wildlife in this area and elsewhere.

Impact 3: Prompting greater protections for killer whales in the UK and Iceland

The movements and distribution of KW's remain little understood. This makes identifying threats and coordinating management (particularly across international borders) an ongoing challenge. R4 and R5 demonstrated that the movement patterns and foraging ecology of herring-eating North Atlantic KW's are more complex than previously assumed and this must be taken into account in population assessments. Through photo-identification and acoustic research, R5 demonstrated that not all KW's followed the migratory patterns of herring (their main prey), and that some may have moved to other locations to pursue alternatives, providing valuable new data on species abundance. This research proved important to enabling Iceland's Marine and Freshwater Institute (under the aegis of Iceland's Ministry for the Environment and Natural Resources) to make Iceland's first assessment of KW's based on IUCN criteria (S5). As mentioned in Impact 1, a global IUCN assessment of the conservation status of KW's is not possible due to insufficient information. However, in Iceland, our research has enabled a 'local' IUCN conservation status to be attributed, informing Icelandic policy for ongoing protection and conservation actions for KW's (S6).

The research has further influenced and shaped the management of marine mammal populations in UK waters. Shetland's KW's also utilise waters around Iceland, and measures to protect these populations require international (Iceland, UK and Faroe Islands) cooperation. The Chief Scientific Advisor to DEFRA (2012-2019) states that R5, through acoustic analysis and photo identification, "*established clear links between killer whales in UK and Icelandic waters*" and that "*The UK Government is considering this information in its marine planning and conservation policies*" (S7). NatureScot (Scotland's Nature Protection Agency) have also used this research to inform decisions made under Habitat Regulations (cetaceans are a European Protected Species), also believing the work to have had "*positive influence on the awareness and interest of Shetlanders and tourists regarding killer whales*" (S8).

Impact 4: Informing international and UK guidelines for marine conservation

Acoustic fish tags are used to monitor fish population and distributions, emitting an individually-coded acoustic signal which can be picked up by a receiver to track fish at sea. Acoustic tagging data informs fisheries policy and is used to monitor highly endangered fish stocks. R3 demonstrated that grey seals spontaneously learn to use tag signals as an indicator of food location. By increasing mortality of tagged fish, this 'dinner-bell effect' of acoustic fish tags has obvious implications for any conservation efforts or research that involve their use. As a result, the research has been used by NatureScot to formulate and deliver policy regarding the licencing of tags; to inform guidance on appropriate use; and to inform sectoral management, strategy and marine planning such as the Marine (Scotland) Act 2010 (S8).

The research has also informed published international guidance on the use of fish tags, including from the 'South African Elasmobranch Monitoring' (ELMO, a citizen science project gathering data on South African shark, ray and skate populations, S9i); and 'Discovery of Sound in the Sea' (DOSIS, a Rhode Island University and Inspire Environmental website making peer-reviewed content and concepts related to acoustic monitoring accessible to all readers, S9ii). R3 has also been made accessible to public audiences through 'Ocean Bites' (also Rhode Island University, "*sharing scientific information translated by experts*" S9iii) and 'Phys.org' (a UK-based science, research and technology news aggregator, S9iv).

Furthermore, the World Wildlife Fund (WWF) have used R4 to inform their Acoustic Monitoring Guidelines. With over 5 million supporters and a network across 100 countries, WWF also provides education and information to conservationists, including guidance on use of technology. In recent years, acoustic monitoring has become increasingly accessible due to technological advances and readily available devices such as smartphones or autonomous recorders. WWF's Acoustic Monitoring Guidelines (S10) are aimed at field ecologists and marine conservation practitioners, providing information on selection and deployment of acoustic sensors and data analysis. These guidelines cite R4, specifically on guidance for the use of acoustic monitoring to determine the abundance and movement patterns of KW's and other endangered wildlife (S10, pp 26, 69, 73). The guidelines also use an image from Deecke's research of KW calls recorded in Glacier Bay, Alaska (S10, pp 1, 2).

Impact 5: Citizen science in action

Deecke is a member of the Icelandic Orca Project which runs a website and Facebook group, to which the public post pictures and ask for identification or information. Through Deecke's regular contributions, drawing on and citing research where relevant, new contacts have been made. One of these was the writer James Cheshire, who with co-author Oliver Uberti, wrote a book about using innovative techniques to track animal migrations around the world, aimed at the general reader. Cheshire contacted Deecke and spent several days shadowing and interviewing him on a research expedition off the coast of Iceland. Cheshire and Uberti then went on to write a 'coffee table book', using high quality graphics and maps, *Where the Animals Go: Tracking Wildlife with Technology in 50 Maps and Graphics*. By showcasing the Icelandic Orca Project's use of citizen science via social media to track North Atlantic KW's, the book (174 pages) has contributed to public awareness about KW's and their habitats. It has received much media attention (S11), winning several prizes, including Best Overall and John C. Bartholomew Award for Thematic Mapping (2017 British Cartographic Society Awards) and the London Book Fair Innovation in Travel Publishing Award (Edward Stanford Travel Writing Awards 2016).

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

- S1. John K.B. Ford, James F. Pilkington, Amalis Reira, Mayuko Otsuki, Brian Gisborne, Robin M. Abernethy, Eva H. Stredulinsky, Jared R. Towers, and Graeme M. Ellis (2017). *Research Document 2017/035. Habitats of Special Importance to Resident Killer Whales (Orcinus orca) off the West Coast of Canada*. Canadian Science Advisory Secretariat (CSAS). <https://waves-vagues.dfo-mpo.gc.ca/Library/40613586.pdf>. See p.p. vii, 3, 26, 30, and 31 for reference to Deecke's research.
- S2. Green Marine. (2018, 20 December). *Two new protected areas for B.C.'s resident killer whales*. Green-Marine.org. <https://green-marine.org/2018/12/20/two-new-protected-areas-for-b-c-s-resident-killer-whales/>.
- S3. Testimonial letter from Principal Scientist (North America), SMRU Ltd., on Deecke's contribution to trial for reducing vessel speed in Vancouver Port [Corroborator 1].
- S4. Government of Canada. (2019). A *Species at Risk Act* section 11 conservation agreement to support the recovery of the Southern Resident Killer Whale. <https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/conservation-agreements/southern-resident-killer-whale-2019.html#toc2>. See section 2 'Goal and Purpose'.
- S5. Testimonial letter from Head of Cetacean Research, Marine and Freshwater Research Institute, Iceland, for the contribution of Deecke's research to marine mammals in Iceland gaining a national conservation status based on IUCN guidelines.
- S6. Icelandic Institute of Natural History. (2018). *Red List for Mammals in Iceland*. <https://en.ni.is/resources/publications/red-lists/red-list-mammals>.
- S7. Testimonial letter of support from 2012-2019 Chief Scientific Advisor to DEFRA on the research influencing UK government marine planning and conservation policies.
- S8. Testimonial letter from Marine Planning & Policy Officer for NatureScot on research informing the agencies guidance, strategy and related legislation. [Corroborator 2].
- S9. R3 is referenced as a source by ELMO Africa (S9i, see elmoafrica.org/post/2016/02/12/acoustic-telemetry-a-minimal-invasive-research-method-or-is-it); DOSIS (S9ii, see dosits.org/galleries/technology-gallery/observing-and-monitoring-marine-animals/acoustic-fish-tags/); Ocean Bites (S9iii, see oceanbites.org/are-fisheries-scientists-ringing-the-dinner-bell-for-marine-mammals/); Phsy.org (S9iv, see <https://phys.org/news/2014-11-tags-fish-dinner-bell.html>).
- S10. Browning, E., Gibb, R., Glover-Kapfer P. and Jones K. E. (2017). *Passive acoustic monitoring in ecology and conservation*. WWF Conservation Technology Series 1(2). WWF-UK, Woking, UK. <https://www.wwf.org.uk/sites/default/files/2019-04/Acousticmonitoring-WWF-guidelines.pdf>. See pp 1, 2, 26, 69, 73 for use of research.
- S11. Cheshire, J. and Uberti, O., 2017. *Where the Animal Go*. Particular Books, London, UK. ISBN: 0141982225. Deecke listed as contributor. <http://wheretheanimalsgo.com/contributors/>