

Institution: Durham University
Unit of Assessment: UoA5
Title of case study: Conservation Genetics of the Killer Whale Enabling the Legislative Protection of an Endangered Distinct Population Segment (DPS)
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Listing an endangered DPS under US law (governed by the Endangered Species Act, ESA, of 1973) requires the use of genetic markers to assess the extent of reproductive isolation, direction and pattern of gene flow, and effective size of the DPS under assessment. Professor Hoelzel's group provided these essential data from work in multiple peer-review publications, and in a commissioned report in 2004 in support of a successful petition by the National Marine Fisheries Service (NMFS) to protect the killer whale population residing in the inland waters of Washington State, USA, after it was shown to have declined by 20% in 10 years (Krahn et al. 2004; see volume 79, No.222 of the Federal Register for DPS listing). This formed the foundation for on-going impact on policy and regulation between 2008 and the present, including support in response to petitions filed in 2012 and 2013 (see testimonial from the Branch Chief, NOAA Fisheries). Killer whale sustainability in this region reflects general ecosystem health and supports an economically important whale-watch industry.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>Research led by Professor Hoelzel in the School of Biological and Biomedical Sciences has assessed the units of management and conservation for killer whales (<i>Orcinus orca</i>) worldwide. The killer whale is a top predator species that forms long-term stable social groups ('pods'). These pods are matrilineal in organisation, and so the founding of regional populations will be by a group of individuals related to each other along the matriline. Details of kinship within and among these groups were determined by research conducted in Prof. Hoelzel's group (Pilot et al. 2010), and showed that both males and females often remained in association with maternal kin, with mating apparently happening during temporary associations with other pods. The impact on the genetic structure of populations was reported earlier when regional populations were shown to have fixed matriline marker (mitochondrial DNA) genotypes, and to be differentiated from each other (Hoelzel et al. 1998, 2002, 2007). Each social group specializes in prey choice, and this served as an apparent boundary to gene flow such that populations of different foraging strategists (marine mammal eating compared to fish eating) in the same geographic region ('sympatric' populations) were found to be genetically differentiated from each other (Hoelzel et al 1998). At the same time, it was shown that there was a pattern of genetic isolation by geographic distance within an 'ecotype' (Hoelzel et al. 2002). It was also shown that genetic diversity for the species as a whole was low, suggesting an historical population bottleneck, but not one likely influenced by anthropogenic factors, as it occurred an estimated 150,000 years ago (Hoelzel et al. 1998, 2002). The importance of group activities towards efficient prey capture in the 'southern resident', fish-eating population of killer whales in Washington State waters was demonstrated (Hoelzel 1993), indicating the importance of group composition and stability. Evidence for a population decline and the suggestion that some animals may have starved promoted concern for the future of the southern resident population in particular. It was also demonstrated by Prof. Hoelzel's group that the whales in this population had changed their behaviour in response to anthropogenic disturbance – the increasing number of boats associated with the whale-watching industry in this region (Foote et al. 2004). The change was manifest in 'anti-masking' behaviour such that beyond an apparent threshold level, increasing numbers of boats in association with the whales led to them increasing the duration of their vocal calls. These data were later reviewed in support of new</p>

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regulations (2010 Environmental Assessment; RIN 0648-AV15, pg. 3-28) governing vessel traffic in the vicinity of this population of killer whales. Although there was evidence for ongoing gene flow at a low level, various analyses showed that the southern resident population was differentiated from all other local populations, and that the rate of gene flow was low enough for the population to be designated a DPS (Hoelzel et al 1998, 2002, 2007). These data were summarised in a report commissioned by NMFS for the ESA listing procedure (Hoelzel 2004), and both the report and supporting papers were cited extensively by the proposers in support of their petition for DPS listing and in support of later policy reviews and implementations.

3. References to the research (indicative maximum of six references)**Papers on population genetics and behaviour cited in petition and review to support case for listing**

Hoelzel, A.R., Hey, J., Dahlheim, M.E., Nicholson, C., Burkanov, V. & Black, N. 2007. Evolution of Population Structure in a Highly Social Top Predator, the Killer Whale. *Mol. Biol. Evol.* **24**:1407–1415

Hoelzel, A.R., Natoli, A., Dahlheim, M., Olavarria, C., Baird, R.W., Black, N. 2002. Low world-wide genetic diversity in the killer whale (*Orcinus orca*); Implications for demographic history. *Proc. Royal Soc. B* **269**: 1467-1475.

Hoelzel, A.R., Dahlheim, M. and Stern, S.J. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the eastern North Pacific, and genetic differentiation between foraging specialists. *J. Hered.* **89**:121-128

Hoelzel, A.R. 1993. Foraging behaviour and social group dynamics in Puget Sound killer whales. *Animal Behaviour*, **45**:581-591.

Report commissioned by BRT in support of petition:

Hoelzel, A. R. 2004. Report on killer whale population genetics for the BRT review on the status of the southern resident population. Unpublished report to the National Marine Fisheries Service. 27 pg. (supported by NMFS grant)

Further studies supporting case that were in support of ongoing conservation efforts – evidence of ongoing impact (1 example):

Foote, A.D., Osborne, R.W. & Hoelzel, A.R. 2004. Killer whale anti-masking response to whale-watcher boat noise. *Nature* **428**: 910.

Pilot, M., Dahlheim, M.E. & Hoelzel, A.R. 2010. Social cohesion among kin, gene flow without dispersal and the evolution of population genetic structure in the killer whale (*Orcinus orca*). *J. Evol. Biol.* **23**:20-31

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

The primary impact of this study comes from on-going efforts to protect the 'Southern Resident' killer whale population in Washington State waters. Long-term data suggesting a population decline convinced local management authorities that protection under the Endangered Species Act was necessary. Supported by Prof Hoelzel's research establishing genetic isolation (e.g. Hoelzel et al. 1998, 2002), the Southern Resident community was designated as a Distinct Population Segment in 2005 (the smallest division of a species permitted to be protected under the US Endangered Species Act), which led to the group being listed as an endangered species by the National Marine Fisheries Service (NOAA Fisheries). The listing process is intentionally long and

difficult, with relatively few applications succeeding. Prof Hoelzel's research was vital in the designation of the killer whale as endangered, with his work "important to the original listing" and continuing "to inform status updates and response to petitions under the ESA" (NOAA testimonial). The initial petition in 2001 cited Prof. Hoelzel's work 23 times, the status reviews in 2002 and 2004 cited Prof. Hoelzel's work 12 and 26 times respectively. The ESA listing provided the "foundation" for a variety of organisations to develop policies and action plans to help recovery of the killer whale DPS. Prof Hoelzel's research has provided academic evidence in support of the 'Determination of Critical Habitat' and a 'Species Recovery Plan' that are legally required following the listing process, and including support for legislation providing new regulations on vessel activities approved and established in 2011.

The killer whale is an alpha predator species that has a key impact on local species communities and ecosystems, as the primary predator of other marine mammals, and an important predator of fish species. It is also a high profile flagship species of great interest to the public through exposure in the media, 'whale-watching' businesses, and at aquarium parks. At the end of 2012 there were only 84 whales in the Southern Resident population, which supports a significant whale-watching industry on the Washington coast (76 boats and 500,000 passengers per year in 2006 at \$100 per passenger; Oliver 2008). According to a report from 2001 (Hoyt 2001) the overall value of the local whale watching industry was assessed as \$66.2M annually and wildlife watching (whales and other animals) in Washington State produced an annual economic output of \$1.78BN, maintaining over 21,000 jobs (more than Microsoft and almost as many as Boeing).

In 2008 NOAA completed a Recovery Plan identifying actions needed for the conservation and recovery of the Southern Residents (NMFS 2008). Again influenced by Prof Hoelzel's work, this plan was reviewed in 2011. Since the species was listed, "a variety of federal, state, non-profit, and local organisations implemented conservation actions to benefit the whales, their salmon prey, and the ecosystem" (NOAA testimonial). Results from this include:

- NOAA, the Environmental Protection Agency and the Washington Department of Ecology are working to reduce pollution in the Puget Sound, such as reducing agricultural run-off and examining the impacts of flame retardants (PBDEs) on the killer whales (NOAA testimonial).
- An oil spill response plan has been specifically developed for killer whales in the event of a major spill in Washington and Oregon State (Oil Spill Response and Killer Whales).
- Noise reduction regulations were enacted in 2011 to reduce disturbance from the significant fishing and whale-watching industry (Be Whale Wise). Vessels are now prohibited from approaching within 200 yards of a killer whale and must not park in front of their path when in the inland waters of Washington State. This work was supported in part by data from Prof. Hoelzel's lab on the quantifiable impact of boat noise on the behaviour of affected whales (Foote et al. 2004).

Prof Hoelzel's work has also informed the submission of recent petitions calling for changes to the status of the southern resident killer whale under the Endangered Species Act. For example, in August 2012 a petition submitted by the Pacific Legal Foundation, on behalf of the Center for Environmental Science Accuracy and Reliability, Empresas Del Bosque, and Coburn Ranch, called for the Southern Residents to be delisted under the ESA. Both the petition and the resolution of the case (rejecting delisting, consistent with comments provided by Prof. Hoelzel) "relied heavily" on a paper from Prof Hoelzel's lab (Pilot et al. 2010).

Prof Hoelzel has been thanked repeatedly by stakeholders involved in researching and protecting

the killer whales, for “numerous contributions on killer whale genetics and valuable insights into killer whale stock structure” (NOAA testimonial).

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

Center for Biological Diversity (2001) Petition to list the southern resident killer whale (*Orcinus orca*) as an endangered species under the endangered species act.

http://www.biologicaldiversity.org/species/mammals/Puget_Sound_killer_whale/pdfs/petition.pdf

Krahn, M.M., et al. (2002) Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-54, 133 p.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples (2004) 2004 Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. Commerce, NOAA Tech. Memo. NMFSNWFSC-62, 73 p.

50 CFR Part 224 [Docket No. 041213348–5285–02; I.D. 110904E] RIN 0648–AS95 Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales. Federal Register, Vol 70, No. 222/ Friday November 18, 2005.

NMFS report (2006) Designation of critical habitat for southern resident killer whales.

<http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-CH-Bio-Rpt.pdf>

Oliver (2008) Recovery plan for southern resident killer whales (*Orcinus orca*). NOAA NMFS report: <http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf>

50 CFR Part 224 [Docket No. 070821475–81493–01] RIN 0648–AV15 Protective Regulations for Killer Whales in the Northwest Region Under the Endangered Species Act and Marine Mammal Protection Act. Federal Register, Vol. 74, No. 144, Wednesday, July 29, 2009.

RIN 0648–XV19 Endangered and Threatened Species; Initiation of 5–Year Review for Southern Resident Killer Whales. Federal Register, Vol. 75, No. 65, Tuesday, April 6, 2010.

50 CFR Part 224 [Docket No. 070821475–91169–02] RIN 0648–AV15 Protective Regulations for Killer Whales in the Northwest Region Under the Endangered Species Act and Marine Mammal Protection Act. Federal Register, Vol. 76, No. 72, Thursday, April 14, 2011.

NMFS (2011) 5-year review: summary and evaluation. <http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/KW-review-2011.pdf>

Testimonial from the Branch Chief, Protected Resources Division, NOAA Fisheries (attached).