Institution: 10007857 – Bangor University

Unit of Assessment: 07 Earth Systems and Environmental Sciences

Title of case study:
New DNA forensics tools improve sustainable fisheries management and reduce wildlife crime

1. Summary of the impact (indicative maximum 100 words)

Application of Bangor's DNA forensic research has had major impacts on the management and control of illegal wildlife trade. After initial work providing evidence for criminal prosecutions with wider deterrent effects on wildlife crime, Bangor-led research went on to apply these techniques to trace fish (products) to their source populations to ban illegal, unreported and unregulated fishing practices. Since 2009, this work has improved stock management by the UK government and European Commission, directly affected the Common Fisheries Policy reform and has been implemented by the Marine Stewardship Council as a verification tool for correct labelling of products.

2. Underpinning research (indicative maximum 500 words)

Bangor research to develop the use of genetic markers to determine the source populations of animals and animal products by Prof. R. Thorpe (1996 - present) and Prof. G. Carvalho (2005 - present) et al. was born from the need for a legal framework and validation of traceability tools, in which DNA could be recovered from animal parts and products. Wildlife crime is now the world's third largest illegal trade and DNA forensic techniques are increasingly used in its prosecution. Crucial early research demonstrating the potential of this field for conservation programs and law enforcement was conducted at Bangor, in collaboration with Dr R. Ogden and Dr R. McEwing, co-founders of a Bangor University spin-out company in 2003 called Wildlife DNA Services and both Honorary Research Associates at Bangor since 2007. Specifically, **novel genetic markers suitable for forensic analyses were developed** (3.1) and for species identification in Asian black bear, badger, rhinoceros and birds of prey (e.g. 3.2; 3.3). In a substantial further development, Bangor University led an important (2008-2011) EU FP7 project "Traceability of fish populations and fish products" (FishPopTrace – FPT) coordinated by Carvalho, with significant collaboration from TRACE Wildlife Forensics Network, an NGO established by Ogden and McEwing.

Led and coordinated by Carvalho, the €4M international FPT consortium comprised 15 different institutes in Europe. Contributing project researchers at Bangor were Dr M. Taylor (Lecturer 2005-2011, Senior Lecturer 2011-2012) and Research Fellow Dr S. Helyar (2008-2011). **Aimed specifically at bridging the gap between academic science, policy makers and end-users**, it focused primarily on **identifying, mapping and monitoring fish stocks for policy makers and fisheries managers,** in relation to traceability and Illegal, Unreported and Unregulated Fishing (IUU). The project's research generated applications and tools to enable control and enforcement of fisheries management strategies by developing a traceability framework based on molecular genetics, otolith chemistry and morphometrics: **traceability tools up to forensics standards for the whole stock-to-fork chain**. The first research step was to develop genetic markers for four marine fish species (cod, herring, sole and hake; all economically important EU priority species for enforcement and/or conservation that are relatively widespread and known to exhibit population structure) to enable detection of their populations of origin and assess their diversity (3.4). **Significant research outputs validated the new traceability tools for specific stocks** of these four species (e.g. 3.5; 3.6), after which they could be directly applied for IUU regulation purposes.

FPT was the first major project to produce tests that identify the geographic origin of marine fish for fisheries enforcement with sufficient certainty and level of validation to meet forensic standards in court.

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

Bangor authors are in **bold**. Citation counts obtained through Google Scholar (October 2013).

Selected publications:

(3.1) **Dawnay, N.**, Ogden, R., McEwing, R., **Carvalho, G.R. & Thorpe, RS.** 2007. Validation of the barcoding gene COI for use in forensic genetic species identification. *Forensic Science International* **173:** 1-6. **DOI:** 10.1016/j.forsciint.2006.09.013. In peer-reviewed journal, 100 citations

(3.2) **Dawnay, N.,** Ogden, R., Wetton, J.H., **Thorpe, R.S.** & McEwing, R. 2009. Genetic data from 28 STR loci for forensic individual identification and parentage analyses in 6 bird of prey species. *Forensic Science International – Genetics* **3:** e63-e69. **DOI:** 10.1016/j.fsigen.2008.07.001. In peer-reviewed journal, 15 citations

(3.3) **Peppin, L.,** McEwing, R., Ogden, R., Hermes, R., Harper, C., Guthrie A. & **Carvalho, G.R**. 2010. Molecular sexing of African rhinoceros. *Conservation Genetics* **11**: 1181-1184. **DOI**: 10.1007/s10592-009-9912-2. In peer-reviewed journal, 9 citations

(3.4) Nielsen, E.E., Cariani, A., Mac Aoidh, E., Maes, G.E., Milano, I., Ogden, R., **Taylor, M.,** […], **Helyar, S.,** […], FishPopTrace consortium & **Carvalho, G.R.** 2012. Gene-associated markers provide tools for tackling IUU fishing and false eco-certification. *Nature Communications* **3:** 851. **DOI**:10.1038/ncomms1845. In peer-reviewed journal, 10 citations (In REF2014 ID 0601).

(3.5) Limborg, M.T., **Helyar, S.J., DeBruyn, M., Taylor, M.I.,** Nielsen, E.E., Ogden, R., **Carvalho, G.R.,** FPT Consortium & Bekkevold, D. 2012. Environmental selection on transcriptome-derived SNPs in a high gene flow marine fish, the Atlantic herring (*Clupea harengus*). *Molecular Ecology* **21**: 3686–3703. DOI: 10.1111/j.1365-294X.2012.05639.x. In peer-reviewed journal, 13 citations (In REF2014 ID 07121).

(3.6) **Helyar, S.J**., Hemmer- Hansen, J., Bekkevold, D., **Taylor, M.I.,** Ogden, R., Limborg, M.T., Cariani, A., Maes, G.E., Diopere, E., **Carvalho, G.R.** & Nielsen, E.E. 2011. Application of SNPs for population genetics of non-model organisms: new opportunities and challenges. *Molecular Ecology Resources* 11 (Suppl. 1), 1–14. DOI: 10.1111/j.1755-0998.2010.02943.x In peer-reviewed journal, 64 citations

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

Impacts on wildlife crime law enforcement

The successful and **novel application of genetic markers in a forensic context** led to a Bangor University spin-out company in 2003 called Wildlife DNA Services. Its cofounders (Ogden and McEwing) went on to establish the NGO TRACE Wildlife Forensics Network in 2007. Through expansion of the TRACE Network, and in association with Bangor University, its Programme Director, Ogden, has applied the outcomes of the Bangor research (3.1-3.3) in major international wildlife forensics initiatives that have been instrumental in expanding this pioneering field and in **improving the effectiveness of the enforcement of wildlife crime law.** For example, DNA-based sexing markers developed at Bangor (3.3) are being used for identification of poached rhino carcasses in South Africa and are incorporated in the Rhino DNA Index System (RhODIS): a database where, since 2011, DNA profiles for all South African rhinos are being accumulated. In its first year, over 5000 rhinos had been profiled and 1900 test kits including the Bangor markers were distributed as part of the programme to halt poaching.[2] These markers are also included in the Scottish database launched in April 2013, that aims to include every rhino (artefact) at Britain's zoos and museums to counter the growing criminal threat of these horns being stolen for the black market through increased risk of detection and successful prosecution[2].

Additionally, global organisations such as the Royal Society for the Prevention of Cruelty to Animals and the Partnership for Action against Wildlife crime (PAW) use the research in prosecutions against wildlife crimes such as poaching and illegal trade[1,10]. Bangor research on birds of prey in particular (3.1) has been fundamental for the Animal Health and Veterinary Laboratories Agency (AHVLA), in **prosecutions linked to the illegal capture and breeding of endangered birds** and investigations on the legitimacy of ownership of birds of prey in the UK. Between 2009 and 2012, the work has led directly to two convictions (2009, 2010)[10], and 220 samples have been analysed in so-called compliance cases that did not proceed to court. Of these, 61 were from two interlinked cases but a total of 39 keepers had birds tested, **with a well-recognised deterrent effect on illegal trade**. The Bangor method was chosen because of the

quality of the markers, ease of use and transparency and the DNA analyses were crucial in determining the legitimacy of ownership of the birds. The method (3.1) has further been used to develop tests for golden eagle, peregrine falcon, merlin, goshawk, barn owl, common buzzard and palm cockatoo: advances which further empower restriction of the illegal bird trade[1].

Impacts on IUU regulation and sustainable fisheries management

The traceability tools created by the FishPopTrace (FPT) research have **directly impacted international stock management of fisheries**. The Marine Stewardship Council (MSC) uses the **regional identifiers for Atlantic cod** (*Gadus morhua*) developed by FPT to **provide assurance that MSC-certified products are correctly labelled**, and to identify any areas of concern in the supply chain[9]. In 2012, 86 products were tested using the FPT identifiers, verifying correct labelling of 99% of MSC-labelled cod. Furthermore, the DNA testing program also helps to deter MSC-certified companies from mislabelling products, which **lowers the likelihood of fraud in the supply chain**. The MSC will continue to carry out an annual DNA testing program using the FPT markers and is collaborating with TRACE (since 2011) to expand the range of tests.[9] Further evidence for the importance of the Bangor work for MSC efforts on sustainable fishing, comes from their recent (2013) appointment of Carvalho as an independent advisor on DNA testing in relation to fisheries certification.

Key mechanisms by which **FPT has had constructive, political impact on individual member states decision-making to apply novel technologies to fisheries regulations** are through the provision of data, information, and dissemination of infrastructure directly resulting from the FPT proceedings. For example, in April 2012, the UK Government launched a novel Defra-funded programme to implement the use of FPT research outputs to improve fish traceability in UK stocks of four economic priority fish species (Geographic traceability tools for commercial fish and fish products - FA0118). The programme transfers the FPT novel forensic DNA marker systems directly to stocks relevant to government, industry stakeholders and non-governmental organisations in the UK, enabling self-regulation, monitoring and enforcement of the fishing industry at a scale not previously possible.

Impacts on EU Council regulations through the FishPopTrace project

In line with its commitment to engage with policy, the FishPopTrace (FPT) consortium translated its research and technological advances into policy recommendations and accessible information to managers and stakeholders. The consortium created a **concise policy document which analyses the current policy framework for traceability of fish and fish products to their geographic origin, tackling fish piracy and consumer fraud** (available on the FPT website). Specifically targeting policies and legislation of the Common Fisheries Policy (CFP) on the key CFP aim of promoting sustainability through conservation of genetic resources, the consortium further submitted two contributions to the public consultations launched by the European Commission (EC) for the CFP Control Reform and the CFP Reform. These contributions have had a **demonstrable direct impact on the reform of the policy**: the EU's decision to endorse the use of advanced genetic and morphometric tools for fisheries management. The project is specifically highlighted in the Impact Assessment report that followed the consultation and underpinned the major proposal for reform of the CFP control regime[3-5]. The project's methodology and findings are also cited throughout in the 2011 reference report of the Joint Research Centre of the European Commission (JRC) on deterring illegal activities in the fisheries sector[6].

Impacts on policy debate and pathways to impact

Additional impact of Bangor research on EU fisheries policy comes from **influencing policy debate** through FPT's highly valued participation in international meetings and workshops on traceability and control in the fisheries sector, organised by JRC, Food and Agriculture Organization (FAO) and other global authorities on fisheries management. Here, the potential of advanced technologies and appropriate strategies for transfer into more efficient fisheries control schemes was discussed directly with relevant authorities on fisheries management at a political and industry level[7]. Because of the perceived importance of the project's findings, EU and FAO policy makers subsequently attended FPT meetings, adding further reach to the project findings[7].

A recommendation from the 2009 FishPopTrace consultation document [p. 6,13] that was taken up by the EC is exemplified by the JRC decision in 2009 to **establish an Expert Group** on new ways to comply with Data Collection Regulation and integration of sustainability programmes (kick-off meeting March 2012[8]). As a direct impact of the expertise developed through FPT, the group has engaged two population geneticists, including Carvalho, to work on **developing new integrative tools for data collection**[8].

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

1. A formal statement from the Wildlife Licencing and Registration Service Compliance specialist at the AHVLA confirms claims on the use of the bird of prey research by the AHVLA.
2. A presentation by the University of Pretoria Scientists on the RhODIS project, demonstrating the relevance of Peppin's markers and the scale of the project can be found at: http://www.rhinoresourcecenter.com/pdf_files/132/1321657369.pdf.
   An email conversation with the lead scientist on the Scottish rhino project is available on request and can confirm the inclusion of the Bangor sexing markers. A press release on the database is available at:
   http://www.scotland.gov.uk/News/Releases/2013/04/rhinodna09042013
3. European Commission, 2008. Proposal for a council regulation establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy. COM(2008) 721 final. Available at:
   http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0721:FIN:en:PDF.
   FishPopTrace is explicitly mentioned on p.4 in relation to traceability seminars organised "integral to the Common Fisheries Policy reform".
4. European Commission, 2008. Commission Staff Working Document accompanying the proposal for a council regulation. Establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy. *IMPACT ASSESSMENT*. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2008:2760:FIN:EN:PDF
   FishPopTrace is explicitly mentioned on p.57.
5. FPT had an impact on the CFP Control Regulation (Regulation (EC) No 1224/2009; (paragraph 16 and Article 13). Available at:
   http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:343:0001:0050:EN:PDF
   FishPopTrace participated actively through advice and communication with the European Commission during the preparation phase of this regulation.
6. Martinsohn, J.T. 2011. DETERRING ILLEGAL ACTIVITIES IN THE FISHERIES SECTOR. Genetics, Genomics, Chemistry and Forensics to Fight IUU Fishing and in Support of Fish Product Traceability. European Commission Joint Research Centre, Ispra, Italy. Available at:
   http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/16295/1/jrc_rr_deterring%20illegal%20fisheries_for_web-2_180511.pdf
7. A list of workshops and meetings of FPT delegates with leading fisheries authorities, demonstrating the tight link between FPT and policy and management developments, can be provided on request.
8. a4a Kick-off meeting report 28th February to 2nd March, 2012 JRC, Ispra, Italy. Available on request.
9. Marine Stewardship Council. 2012 DNA Testing of MSC-Labelled Products. Methodology and Results. Available at: http://www.msc.org/about-us/credibility/dna-testing-methodology-and-results-2012. Related press releases mentioning FishPopTrace and its results are available at: http://www.msc.org/newsroom/news/dna-testing-delivers-positive-results-for-msc-traceability-standard-and-validation-programme (2010) and http://www.msc.org/newsroom/news/latest-dna-results-confirm-integrity-of-msc-chain-of-custody/?searchterm=dna (2013).
10. A list of cases in which the Dawnay et al. 2009 outputs were instrumental in obtaining conclusive evidence in court can be found at: http://www.tracenetwork.org/wp-content/uploads/2012/08/5-WILDLIFE-RELATED-INVESTIGATIONS-INVOLVING-DNA-EVIDENCE-NOV-11.xls (Sep-09 and Nov-10 conviction dates).