Institution: Bournemouth University
Unit of Assessment: UOA17
Title of case study: Policy-making and species eradication: Protecting European biodiversity from the ecological impacts of non-native fish.

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

Bournemouth University (BU) research delivers the evidence base on which to develop regulations, policy and management programmes to protect European biodiversity from the adverse impacts of non-native fish. It reveals where introduced non-native species have damaging impacts and, as in the majority of cases, where there is little ecological consequence but substantial socio-economic benefits. The research has been applied to EU risk assessment and quarantine measures for the management of non-native species. It also provides the scientific base for the Environment Agency's eradication of *Pseudorasbora parva,* more commonly known as topmouth gudgeon, from UK freshwaters. This is protecting a fisheries industry worth over £3 billion per annum.

2. Underpinning research (indicative maximum 500 words)

BU's underpinning research focuses on the ecology and management of non-native fish. These fish species are introduced to enhance ecosystem services, such as aquaculture and angling, to deliver socio-economic benefits. Following their introduction, however, the fish may develop sustainable and invasive populations. As they disperse and colonise new habitats, they cause ecological and economic damage. Consequently, it is important for policy-makers and managers to identify and differentiate between the non-native fish species that would deliver socio-economic benefits and those that are likely to develop invasive and damaging populations.

BU research by Gozlan (2007 to present), Britton (2007 to present) and Andreou (2011 to present), supports the identification of problematic species and their management by developing new knowledge and tools in the following areas: technical definitions and criteria on ecological impacts of non-native fish (P1); empirical evidence that quantifies the ecological impacts of non-native fish in the UK (P2 & P3); and decision-making tools that support the management and eradication of non-native fish in the environment (P3 & P4).

These have developed through three components:

(1) Researchers have used meta-analyses and theoretical and review-based approaches to develop definitions relating to non-native fish and identify the evidence base on which to develop policy and management. BU research has advanced the understanding of the impacts of non-native and invasive fish, and how these have previously been misinterpreted by policy-makers. These showed that only small proportions of all introduced non-native fish become invasive and have significant ecological and economic impacts (P1).

(2) BU conducted experimental and field research on the impacts *Pseudorasbora parva* has on native biodiversity (P2 & P3). This native Southeast Asian species was initially introduced into Europe in the 1960s and has since become highly invasive, achieving a pan-continental distribution. Research has revealed *Pseudorasbora parva* as a healthy carrier of the intracellular pathogen *Sphaerothecum destruens*, more commonly known as the Rosette Agent (P2 & G1). It belongs to a newly discovered pathogen group that includes a major pathogen for frogs and humans. This was first discovered by Gozlan prior to joining BU, when he revealed that *Sphaerothecum destruens* transmission from *Pseudorasbora parva* to other fish species resulted in high mortality rates. Since joining BU in 2007, the research has progressed to reveal substantial impacts of *Sphaerothecum destruens* on specific native UK fish, including high mortality rates, spawning suppression and emaciation

(P2 & G1). This has resulted in a number of significant publications where BU researchers were the lead and corresponding authors (e.g. P2).

(3) Researchers have developed risk-based management decision-making tools for non-native fish. These enable managers to make objective decisions that reflect the risk level of that species in the environment (P4, P5 & G2). These tools provide transparent outputs on the optimum approaches for managing non-native fish in the environment.

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

Research papers

P1. Gozlan, R.E. (2008) Introduction of non-native freshwater fish: Is it all bad? *Fish & Fisheries*, 9, 106–115. DOI: 10.1111/j.1467-2979.2007.00267.x.

P2. Gozlan, R.E., Whipps, C., Andreou, D. and Arkush, K. (2009) Identification of a rosette-like agent as Sphaerothecum destruens, a multi-host fish pathogen. *International Journal of Parasitology* 39(10), 1055–1058. DOI: 10.1016/j.ijpara.2009.04.012.

P3. Britton, J.R., Davies, G.D. and Harrod, C. (2010) Trophic interactions and consequent impacts of the invasive fish Pseudorasbora parva in a native aquatic foodweb: a field investigation in the UK. *Biological Invasions*, 12(6), 1533–1542. DOI: 10.1007/s10530-009-9566-5.

P4. Britton, J.R., Copp, G.H., Vilizzi, L., Brazier, M. and Davies, G.D. (2011) A modular assessment tool for managing introduced fishes according to risks of species and their populations, and impacts of management actions. *Biological Invasions*, 13(12), 2847–2860. DOI: 10.1007/s10530-011-9967-0.

P5. Britton, J.R., Davies, G.D. and Brazier, M. (2010) Towards the successful control of Pseudorasbora parva in the UK. *Biological Invasions*, 12(1), 125–131. DOI: 10.1007/s10530-009-9436-1.

P6. Gozlan, R.E., Burnard, D., Andreou, D. and Britton, J.R. (2013) Understanding the threats posed by non-native species: Public vs. Conservation managers. *PLoS One*, e53200. DOI: 10.1371/journal.pone.0053200.

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G1. Gozlan, R.E. (2006–2009). Prevalence, impact and life cycle of an emerging endemic disease: the rosette-like agent – FC1176. £82,110. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13959&FromSearch=Y&Status=3&Publisher=1&SearchText=rosette%20&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description.

G2. Britton, J.R. (2012–present). Reducing the risk of non-native species in Europe. European Union. £112,000. http://www.rinse-europe.eu.

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

The research has provided the evidence-base for the regulation and management of invasive fish species. This has enabled regulatory and business organisations to make informed conservation management and policy decisions. Ultimately this protects European biodiversity from the adverse ecological impacts of invasive fish species.

European impact: regulation and policy development

The technical definitions and criteria on the ecological impacts of non-native fish (P1) have been applied to an EU directive for the management of non-native species. The work was used to define how to measure the impacts of introduced fish on the aquatic environment and ecosystem services. This provides stringent definitions of the ecological impact of a non-native fish (P1 & R1). This was communicated through policy meetings and reports (R1 & R2) as follows.

In 2008, in response to the Annexes of Regulation (EC) No 708/2007 (R3), Gozlan was invited as a 'technical expert' to attend a policy meeting in Brussels. The purpose of the meeting, held at DG Fisheries, was to inform the risk assessment and quarantine policies for non-native fish. Gozlan was invited in response to publication P1 (R4). The EU commissioner has since confirmed that Gozlan's definition of what constitutes an ecological impact was used by the European

Commission for the Regulation (R5). The development of the risk assessment and quarantine processes to which the research contributed, was completed within the EU FP6 project 'IMPASSE' (R1).

Specifically, the definitions on ecological impact from P1 and on quarantine from R2 were used to develop the application and risk assessment processes (Annexes I and II – Articles 6, 9 and 11) (R3) and informed the Regulation (Article 21, Annex III). This ultimately means that if any organisation or business applies for permission to import and introduce a new non-native freshwater fish species into a European country, they must complete a risk assessment – based on BU's definitions of ecological impact. The risk assessment then goes for expert evaluation and, if approved, the applicant must impose a period of quarantine on those fish before their release – again based on BU definitions. These risk assessment and quarantine measures are now in use across the European Union and are a fundamental perspective of the import rules governing non-native fish in Member States. This is an excellent case of how BU research has informed public policy at an international scale.

UK impact: eradication of a non-native species

Freshwater fisheries in England and Wales are worth approximately £3 billion per annum. BU research is having a major impact on aspects of their management, specifically relating to non-native fishes involved in the angling and aquaculture industries such as *Pseudorasbora parva*.

Research conducted at BU between 2008 and 2013 revealed the ecological impacts *Pseudorasbora parva* has on native fishes (P2, P3 & G1), quantified this impact (P4 & G2) and demonstrated the difficulty of their detection in the wild (G2). The BU research is currently being used as the evidence base to support the Environment Agency's *Pseudorasbora parva* eradication programme (P4&P5). A small programme to eradicate specific *Pseudorasbora parva* populations commenced in 2005, targeting populations where their risk of dispersal was high. Only one population was eradicated each year to 2008. Since 2008 and following the publication and dissemination of BU's major research findings on the species (P2-P4), the programme has gathered substantial momentum nationwide and gained government funding. Consequently a further 11 populations have now been eradicated (Fig. 1; P4 & P5). This has resulted in a substantial reduction in *Pseudorasbora parva*, protecting native fish communities in over 500km of river length from the harmful impacts of invasion (P4 & P5).

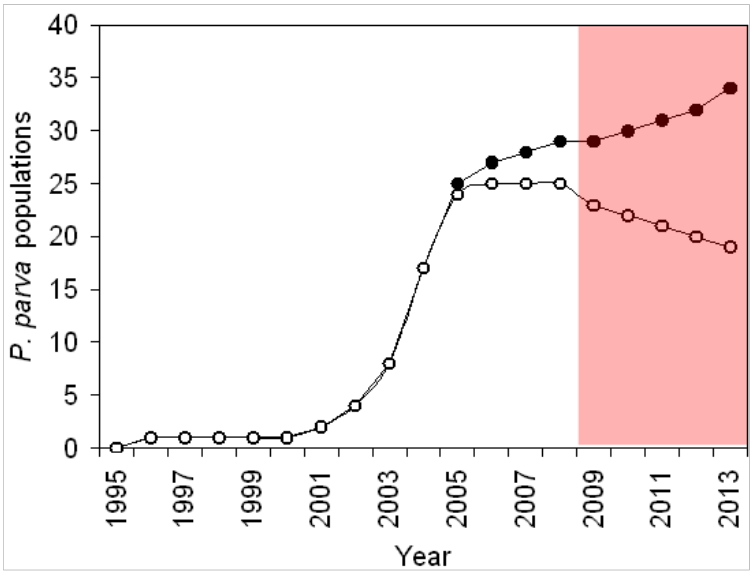

Fig. 1. The number of populations of *Pseudorasbora parva* detected in the wild in England and Wales over time (●) and the actual number (○); the difference in number is due to Environment Agency *Pseudorasbora parva* eradication operations that were triggered by BU research findings. The shaded box signifies the 2008–13 impact period.

Through discussions and decision-making in 2011 and 2012, the Department for Environment, Food and Rural Affairs (DEFRA) and the Welsh Assembly committed to eradicating all known

populations of *Pseudorasbora parva* in their countries by 2017 (R6). This is a major policy decision as there are at least 19 populations still remaining (Fig. 1). This is the first non-native fish species eradication attempt from UK freshwaters. It represents a substantial shift in public policy by authorities that are, by tradition, extremely risk averse and rarely manage non-native species in this manner. To emphasise this, the eradication of *Pseudorasbora parva* is only the second ever eradication attempt of a non-native vertebrate species in the UK after the eradication of the coypu *Myocastor coypus* in the 1980s. The basis of this commitment is the acknowledgement of the severity of their impacts on native fishes, as indicated by BU research (P2–P5) that demonstrates the continued requirement to protect native biodiversity (R7 & R8).

These impacts have been achieved through timely dissemination of research outputs on *Pseudorasbora parva* through popular media and briefing notes. This has ensured policy makers and conservation managers have been made fully aware of the severity of the impact of *Pseudorasbora parva* to UK native biodiversity, enabling them to take commensurate management actions. Indeed, publication P6 will be circulated in the next issue of *Science for Environment Policy* issued by The European Commission's Environment Directorate-General. This publication is circulated to 16,000 policymakers, academics and business people across Europe and assists their development of effective, evidence-based policies.

The commitment by the Environment Agency and DEFRA to eradicate all known populations of *Pseudorasbora parva* from UK waters by 2017 (R6) is the commensurate action to protect native biodiversity from their negative impacts (P2–P5, R3 & R9). Furthermore, BU has revealed the eradication operations to date have already been instrumental in preventing their widespread invasion of UK freshwaters (P4, P5 & fig. 1). BU research impact between 2008 and 2013 goes beyond just informing the management of *Pseudorasbora parva* but has ensured the protection of native biodiversity and an aquaculture and sport angling industry worth over £3 billion per annum.

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

R1. Gozlan R.E. et al. Project no.: 044142, Project acronym: IMPASSE, Environmental impacts of alien species in aquaculture, Coordination Action, Priority FP6 2005-SSP-5A, Sustainable management of Europe's natural resources; D2.2 Review of the impacts of introductions on the aquatic environment and ecosystem services. Available from: http://www2.hull.ac.uk/science/biological_sciences/research/hifi/impasse/documents.aspx [accessed 20 November 2013].
R2. Britton, J.R., Midtlyng, P.J., Persson, G., Joly, J.P., Gherardi, F., Nunn, A.D. and Cowx, I.G. (2009) *Assessment of mitigation and remediation procedures, and of contingency plans*. Report to EC, 54pp.
R3. European Commission Regulation (EC) No 708/2007. Available from: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Regulation&an_doc=2007&nu_doc=708 [accessed 20 November 2013].
R4. Email from European Commission, dated 18 January 2008 (email available on request).
R5. Email from the EU commissioner confirming Gozlan's 2008 definition of what constitutes an ecological impact (P1) was used by the European Commission for the Regulation (EC) No 708/2007 (email available on request).
R6. Environment Agency (2013). DEFRA commitment to eradicating Pseudorasbora parva. Available from: http://www.environment-agency.gov.uk/news/145251.aspx [accessed 20 November 2013].
R7. NNSS (2011) UK Risk assessment of *Pseudorasbora parva* Available from: http://www.nonnativespecies.org//index.cfm?sectionid=51 [accessed 20 November 2013].
R8. Environment Agency alien fish list. Available from: http://www.environment-agency.gov.uk/homeandleisure/recreation/fishing/99055.aspx [accessed 20 November 2013].
R9. Gozlan, R.E. (2009) Prevalence, impact and life cycle of an emerging endemic disease: the rosette-like agent Phase I & II. Defra. 26pp. Available from: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13959&FromSearch=Y&Status=3&Publisher=1&SearchText=rosette%20&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description [accessed 20 November 2013].