Institution: Queen's University Belfast

Unit of Assessment: 7

Title of case study: Reducing the risks of aquatic invasive alien species

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

Irish, UK and European policy and legislation intended to mitigate the ecological damage and economic costs of invasive alien species (IAS) has been influenced by our inter-governmental *Invasive Species Ireland* project. Legislation was enacted through the Wildlife Order (NI) 1985 (as amended) and the EC (Birds and Natural Habitats) Regulations 2010. Our assessments on the 'Killer Shrimp' *Dikerogammarus villosus* contributed to the EU strategy on IAS. Our *Controlling Invasive Riparian Species* project removed invasive plants from over 600 km of riverbank in Ireland and Scotland, restoring native biodiversity, and is cited as a best practice case study in the IAS Strategy for Northern Ireland.

2. Underpinning research (indicative maximum 500 words)

Context: Invasive alien species (IAS), defined as non-indigenous species that have negative ecological impacts as well as serious economic and social consequences, are generally recognized as the second biggest threat to global biodiversity after habitat destruction. IAS are estimated to have cost the EU €12 billion annually over the last 20 years.

Marine aliens: Christine Maggs (NERC Advanced Research Fellow 1992-94; lecturer from 1995), with other academics, post-doctoral researchers (PDRAs) and PhD students, used molecular tools to track seaweed IAS. The key finding in a 1993 monograph and in papers from 1996 onwards was that North Pacific seaweeds were appearing in increasing numbers on European coasts[1,3]. From 1999, Maggs and lecturer Jim Provan demonstrated multiple invasions of particular species, and used the methodology of ancient DNA research on old specimens to track IAS in space and time[3]. Globally, regional invasions of the green seaweed *Codium fragile* had gone unnoticed for up to 100 years, and the red seaweed *Polysiphonia harveyi* had been introduced repeatedly. From 2001, Maggs and lecturer Mark Johnson (who moved to NUI Galway in 2009), with PhD student/PDRA Frédéric Mineur (funded by FP5 ALIENS, 2001-04; AXA Foundation 2009-12), analysed the relative importance of different modes of spread of IAS in a pan-European study of invasive algae[5]. These analyses showed a variety of spread patterns related to different vectors and contributed to developing risk assessments for existing and potential IAS, an important element of the *Invasive Species Ireland* Project.

Freshwater aliens: Jaimie Dick (NERC Fellow 1993-96, then lecturer), with Dirk Platvoet in Amsterdam and a group of QUB PDRAs and PhD students, funded by NERC (partnered with University of Leeds 1999-2002; 2010-13), carried out field and laboratory studies and mathematical modelling of the spread and impacts of IAS in freshwater systems globally. Publications focused on amphipod crustaceans[2], highlighting their keystone roles in freshwaters and showing how IAS significantly impact biodiversity. From 2008 onwards, Dick and European co-workers developed new predictive methodologies, based on functional response curves, which allow forecasting of the likely magnitude of ecological impacts of key IAS, such as the Killer Shrimp *Dikerogammarus villosus*. This is now rated one of the 100 most damaging IAS in Europe (www.europe-aliens.org), with the potential to affect the ecology of major rivers, canals, lakes and some brackish habitats. From 2005, Provan and Maggs, with research student Heather Love, used high-resolution

molecular markers to evaluate the importance of water-borne seeds in spreading the highly invasive riverbank species *Impatiens glandulifera* (Himalayan Balsam)[6]. Patterns of genetic diversity showed that downstream gene flow is very significant, and led to our strategy of control measures implemented on the scale of entire river catchments.

Biosecurity and stakeholder engagement: Research from 2003 to 2006 within Quercus (QUB's biodiversity consultancy unit), on decision-making in IAS management in a cross-jurisdictional context, identified the critical need for a cross-border engagement of stakeholders in risk assessment, risk reduction and policy development[4].

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

1) Maggs, C.A. & Ward, B.A. (1996) The genus *Pikea* (Dumontiaceae, Rhodophyta) in England and the North Pacific: comparative morphological, life-history and molecular studies. *Journal of Phycology,* 32: 176-193.
2) *Dick, J.T.A. & Platvoet, D. (2000). Invading predatory crustacean *Dikerogammarus villosus* eliminates both native and exotic species. *Proceedings of the Royal Society of London B,* 267: 977-983.
3) *McIvor, L., Maggs, C.A., Provan, J. & Stanhope, M.J. (2001). *rbc*L sequences reveal multiple cryptic introductions of the Japanese red alga *Polysiphonia harveyi. Molecular Ecology,* 10: 911-919. 10.1046/j.1365-294X.2001.01240.x
4) Stokes, K.E., O'Neill, K.P., Montgomery, W.I., Dick, J.T.A., Maggs, C.A. & McDonald, R.A. (2006). The importance of stakeholder engagement in invasive species management: a cross-jurisdictional perspective in Ireland. *Biodiversity and Conservation*, 15: 2829-2852.
5) *Mineur, F., Davies, A.J., Maggs, C.A., Verlaque, M. & Johnson, M.P. (2010). Fronts, jumps and secondary introductions suggested as different invasion patterns in marine species, with an increase in spread rates over time. *Proceedings of the Royal Society of London B*, 277: 2693-2701.
6) Love, H., Maggs, C.A., Murray, T. & Provan, J. (2013). Genetic evidence for predominantly hydrochoric gene flow in the invasive riparian plant *Impatiens glandulifera* (Himalayan balsam). *Annals of Botany*, doi:10.1093/aob/mct227, available online at www.aob.oxfordjournals.org

*References that best indicate the quality of the underpinning research

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

Our impact on legislation, designations, policy and practice

Northern Ireland and Republic of Ireland**:** Our research on spread rates, vectors and impacts of IAS in Ireland, and the need for a cross-jurisdictional approach to controls (Sections 2, 3), had informed ten key recommendations to the Governments of Northern Ireland (NI) and the Republic of Ireland (RoI) in the 2004 *Review of Invasive Species in Ireland* by *Quercus*. These were implemented through *Invasive Species Ireland* (*ISI)*,[S1] a joint venture between the NI Environment Agency and the National Parks and Wildlife Service (RoI), contracted to a partnership of Dick and Maggs (QUB), EnviroCentre Ltd (Maguire/John Kelly) and the RoI's National Biodiversity Data Centre. QUB case studies were used to prioritise current and potential IAS and deliver risk assessments and management plans for 20 species. This prioritised list informed the revision of the Schedule 9 lists in the Wildlife Order (NI) 1985 (as amended), as part of the Wildlife and Natural Environment Act (NI) 2011,[S2] giving the Department of the Environment NI (DOENI) the

power to introduce an Order prohibiting sale and spread of IAS. A similar list (e.g. all non-native freshwater crayfish species) based on our risk assessments was used to give the Minister in the RoI powers to prohibit the introduction into the wild of any non-native species listed in the Third Schedule of Regulations 49 and 50 of the European Communities (Birds and Natural Habitats) Regulations 2011.[S3] DOENI's (2013) *IAS Strategy for Northern Ireland*[S4] likewise uses our research as delivered through *ISI.* The *Strategy* was launched by the NI Environment Minister at *ISI*'s annual Stakeholder Forum in May 2013 and addresses international obligations of NI and the RoI on IAS. *ISI* is the main delivery mechanism for the *Strategy*, responsible for implementing seven of its nine key actions designed to reduce the risks of IAS, improve legislation and address international obligations. These key actions were originally developed from our primary research, as a key recommendation in our 2004 *Review.*

Great Britain**:** Publications by Dick and collaborators elucidating the ecological impacts of the Killer Shrimp in mainland Europe led directly to its listing as one of the 100 worst IAS in Europe, explicitly citing two of Dick's research papers[S5]. Following discovery of the Killer Shrimp in Great Britain in 2010, a Task Group of the Environment Agency, DEFRA, CCW, Natural England, and the GB Non-Native Species Secretariat (NNSS) prepared a Rapid Risk Assessment which uses eight of Dick's research papers to develop its biosecurity advice and containment strategies[S6].

Europe**:** Three of Dick's publications are used to highlight and evaluate the dangers of *Dikerogammarus villosus* for European ecosystems in the 2009 document *Technical Support to EU Strategy on IAS: Assessment of the impacts of IAS in Europe and the EU*.[S7] NI and RoI report on *ISI* to the European Network on IAS (NOBANIS). Our research as reported by *ISI* was used in the 2010 *Assessment to support continued development of the EU Strategy to combat IAS*.[S8] This document highlights the leadership role of *ISI*: "…IAS-specific [risk assessment] protocols … may be capable of scaling up to a broader level. Joint risk assessment initiatives between neighbouring member states … are in place for the island of Ireland (Invasive Species Ireland initiative)...". Whereas generally in Europe "there are no structures in places to leverage cooperation" between member states, in Ireland "the Invasive Species Ireland initiative cover[s] the all-island biogeographic unit". These supporting documents were used in drawing up the EC's 2013 proposed Regulation on the prevention and management of the introduction and spread of IAS. Under the Regulation, now under consultation, risk assessments and scientific advice would be used to create a list of 50 target species.

IAS policy in practice: QUB is lead partner of the *CIRB* project (2011-14)[S9] funded under the Interreg IVA programme, co-funded by DOENI and the Department of Arts, Heritage and the Gaeltacht (RoI). *CIRB* promotes native biodiversity by controlling and where possible eradicating harmful riverbank IAS (Giant Hogweed, Japanese Knotweed, Himalayan Balsam and Rhododendron) from 15 river catchments in Ireland and western Scotland using herbicides and biosecurity measures to prevent re-infestation. In three successive years all four species were controlled along 50 km of riverbank in Ireland and 560 km in Scotland, including 100% of Hogweed and 68-100% of the other species, with documented recovery of native biodiversity. Biosecurity measures to prevent anglers accidentally spreading IAS were developed with Inland Fisheries Ireland based on research by Dick and others. They include disinfection kits, a permanent disinfection station[S10], and a "no dip, no draw policy". By June 2013, public engagement events had hosted 35756 visitors; 107 stakeholders were involved, and 39 volunteers had qualified as sprayers.

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

S1) http://www.invasivespeciesireland.com

S2) Wildlife and Natural Environment Act (NI) 2011
http://www.legislation.gov.uk/nia/2011/15/schedule/1/paragraph/9/enacted

S3) European Communities (Birds and Natural Habitats) Regulations 2011
(http://www.irishstatutebook.ie/pdf/2011/en.si.2011.0477.pdf)

S4) An Invasive Alien Species Strategy for Northern Ireland (2013). Department of the Environment. http://www.doeni.gov.uk/invasive_alien_species_strategy_2013.pdf

S5) http://www.europe-aliens.org/speciesTheWorst.do [DAISIE; includes *Dikerogammarus*]

S6) Rapid assessment of: *Dikerogammarus villosus* Date: 14th September 2010.
https://secure.fera.defra.gov.uk/nonnativespecies/alerts/index.cfm?id=3 ["Rapid risk assessment"]

S7) Kettunen M. et al. 2009. Technical support to EU strategy on invasive species (IAS) – Assessment of the impacts of IAS in Europe and the EU (Final module report for the European Commission). IEEP, Brussels, Belgium.

S8) Shine, C. et al. 2010. Assessment to support continued development of the EU Strategy to combat IAS. Final Report for the European Commission. IEEP, Brussels, Belgium.

S9) http://www.qub.ac.uk/research-centres/cirb/

S10) http://www.fisheriesireland.ie/Press-releases/minister-o-dowd-launches-irelands-first-purpose-built-angling-disinfection-facility.html

Individual users/beneficiaries who can be contacted to corroborate claims
Invasive Species Officer, Northern Ireland Environment Agency