

Northern Ireland Species Action Plan
Freshwater Pearl Mussel
Margaritifera margaritifera
March 2005

1 Current Status.

- 1.1 The freshwater pearl mussel *Margaritifera margaritifera* L. is a large bivalve which lives in the bottom of rivers and streams. Its range includes the arctic and temperate regions of western Russia, westwards through Europe to the north-eastern seaboard of North America and southwards to the Iberian peninsula and 'central' Europe. Historically, the species was extremely common in suitable rivers throughout most of its range but its range and abundance is now much reduced.
- 1.2 The habitat of *M. margaritifera* ranges from low pH oligotrophic upland streams which are low in calcium to lowland streams and rivers where calcium levels may be elevated (Young *et al.*, 2000; Chesney *et al.*, 1993).
- 1.3 The species shows differences in life-history strategies across its range. Life span ranges from 30-167 years and maximum size from 30-162 mm (Hastie *et al.*, 2000). Populations in the southern parts of the range typically reach a smaller maximum size in a shorter period and reproduce at a younger age than northern populations (Bauer, 1992).
- 1.4 During the reproductive phase, eggs are retained in the gills of females where they are fertilised and develop into glochidia (larvae) (Zuiganov *et al.*, 1994). On release from the female, the glochidia must infect an appropriate host, usually a juvenile salmonid, to continue development.
- 1.5 Glochidia usually attach to the gills of the host fish where development continues for between 4 and 12 months at which time they detach from the host and settle into the substratum to complete the life cycle.
- 1.6 Self-sustaining populations of mussels of international importance outside Britain and Ireland are now found chiefly in Canada, north-west Russia and north-east Scandinavia (Araujo and Ramos, 2001; Young *et al.*, 2000).
- 1.7 Analysis of British records show that there has been a dramatic and sustained decline in the species, which was especially marked in England and Wales (Cosgrove *et al.*, 2000). The number of Scottish rivers containing healthy populations of *M. margaritifera* has declined over the past 200 years (Cosgrove *et al.*, 2000). A recent survey found that *M. margaritifera* were extinct in approximately two thirds of the Scottish rivers in which they were original found (Cosgrove *et al.*, 2000).

- 1.8** *M. margaritifera* were originally found throughout most of Ireland (Lucey, 1993; Beasley, 1996). Beasley and Roberts (1996a) reported significant declines in the population in County Donegal. Information on the current distribution of *M. margaritifera* in Ireland suggests that the species has undergone a large decline in both absolute numbers and range (Cosgrove *et al.*, 2000). However, there are at least 3 rivers with over one million individuals, with one population containing closer to three million (Moorkens, pers. comm.). Of particular concern is the virtual extinction of the hard-water form *Margaritifera margaritifera durrovensis* (Costello *et al.*, 1998).
- 1.9** Data produced from early surveys in Northern Ireland (Redding, 1693; Harris, 1744; Thompson, 1841; Went, 1947) indicate that *M. margaritifera* were widely distributed. They were and still are more common in the west (Roberts & Preston, 2001). There is no evidence to suggest that they ever occurred in catchments in the east.
- 1.10** In 1990, detailed surveys for *M. margaritifera* were carried out in most major river systems in Northern Ireland (Roberts *et al.*, 1991). Selected rivers were re-surveyed 1996 (Beasley & Roberts, 1996b). Subsequently, more detailed surveys of individual rivers containing *M. margaritifera* were undertaken (Mackie & Hale, 1995; Kelso, 1995; Williams, 1997; O'Loan, 1997; Preston & Mathers, 1997; Preston & Stone, 1998; Preston & Muise, 2000). The counts of mussels in three of the rivers in Northern Ireland (Cladagh/Swanlinbar in Co. Fermanagh and the Owenkillew in Co. Tyrone) would suggest that there may have been up to 10,000 individuals in two of these rivers, while the third (Ballinderry in Co. Tyrone) may have supported a population in excess of 800 individuals. The populations on all other rivers currently containing *M. margaritifera* may be much less and collectively total between 1000 - 2000 individuals.
- 1.11** Mussel populations in Northern Ireland continue to decline as is illustrated by the disappearance from the River Foyle of remnant populations between 1990 and 1996 (Beasley & Roberts, 1996a). Counts in 2004 on the two rivers previously estimated to have population up to 10,000 has found that the population of the Cladagh/Swanlinbar has fallen by an estimated 55% since 2002 and while the Owenkillew did not show such a catastrophic decline there is evidence that the population has fallen. Virtually no mussels below 10 years in age have been found and data would suggest that most individuals are currently in excess of 50 years of age (Beasley *et al.*, 1998).
- 1.12** Although there is little information on the critical number of *M. margaritifera* required to successfully recruit Valovirta (1990) suggests that a density of 500 adults per 100m of river is required for successful recruitment to take place. This figure would vary for different rivers depending on size and water flow.

- 1.13** The size of existing populations of *M. margaritifera* in Northern Ireland may fall below the number of individuals required for successful reproduction and recruitment.
- 1.14** Populations in Northern Ireland are characterised by an ageing cohort of individuals with little or no recent recruitment (Beasley & Roberts, 1996a, 1996b, 1999; Beasley *et al.*, 1998; Mackie, 1992; Mackie & Hale, 1995) and as such none of these populations show an 'ideal' profile, i.e. 20% of the population in the 10 - 20 year age classes as suggested by Young *et al.*, (2001). Without effective mechanisms for the conservation of existing populations and the establishment of enhancement/reinstatement programmes, *M. margaritifera* could disappear from Northern Ireland.
- 1.15** In mainland Britain, pearl fishing is now illegal and it is an offence to harm *M. margaritifera* or its habitat. The species is now fully protected in Great Britain under the terms of the Wildlife and Countryside Act (1981). The species has been identified by the UK Government in its Biodiversity Action Plan (BAP) as a priority for conservation action (UK Biodiversity Steering Group, 1995). The species has been the subject of a European action plan (Araujo & Ramos, 2001).
- 1.16** Internationally *M. margaritifera* is protected under Appendix II of the Bern Convention and listed in Annex II and V of the Habitats & Species Directive (EU Directive 92/43/EEC). It is also listed in the IUCN 1996 Red Data List as 'Endangered'. In Northern Ireland, *M. margaritifera* is listed in Schedule 7 of the Wildlife (Northern Ireland) Order 1985, which makes it an offence to sell mussels or their products.
- 1.17** In the Republic of Ireland, it is illegal to interfere with *M. margaritifera* (Statutory Instrument No. 112, 1990) and pearl fishing is illegal (Moorkens, 1999).

2 Current Factors Causing Loss or Decline.

- 2.1** Failure to recruit - a figure of at least 20% of the population between 10 - 20 years old is often used as an estimate of what constitutes a viable mussel population (Young *et al.*, 2000; Young *et al.*, 2001). The absence of any juvenile mussels on any of the key mussel rivers in Northern Ireland suggests that at present populations of *M. margaritifera* are not successfully recruiting in these rivers. The reasons for this are not clear but the relative densities of mussels and host fish may fall below that required for successful reproduction and host infection.
- 2.2** Pearl fishing - there is recent evidence to suggest that illegal and destructive pearl fishing has been occurring at practically every British and Irish river (Young *et al.*,

2000). Although very few pearl fishermen remain active, pearl fishing could have a critical affect on the low populations remaining.

- 2.3** Pollution - there are numerous examples of the detrimental effects of pollution on *M. margaritifera* (Ziuganov *et al.*, 1994). The basic factors of pollution are siltation, oxygen deficiency, phosphates, nitrates, heavy metals, acidification and eutrophication (Ziuganov *et al.*, 1994). Eutrophication of rivers has been significant in the decline of *M. margaritifera* (Young *et al.*, 2000). This has been largely due to changes and intensification of agriculture, afforestation in the uplands and to a lesser extent effluent discharges from aquaculture and sewage disposal (Young *et al.*, 2000).
- 2.4** Poor riverbank management practices - changes in agriculture over the last century and the intensification of livestock farming has led to overgrazing and soil erosion in many areas. Removal of bankside vegetation due to intensive farming has led to the weakening of river bank structure, erosion and increased sediment loads. Farmland often extends to the edges of rivers where there may be inadequate fencing and protection of the river banks and channel. This ultimately leads to eutrophication and damage to river structure.
- 2.5** Removal of in-river habitat - One of the factors implicated in the decline of *M. margaritifera* in the rest of the UK has been the destruction of suitable river habitat through modification of river beds for drainage and flow regulation schemes and fisheries management (Cosgrove *et al.*, 2000; Young *et al.*, 2000). As a result both freshwater mussels and suitable mussel habitat were removed from stretches of river. Suitable habitat for *M. margaritifera* is often extremely limited. Since both adult and juvenile *M. margaritifera* have very specific in-river habitat requirements, changes to the channel structure may have a potentially lethal impact on mussel beds.
- 2.6** Decreasing abundance of host fish – long-term survival clearly depends on availability of brown trout *Salmo trutta*, as well as its migratory form (sea trout) and Atlantic salmon *Salmo salar*. (Hastie and Cosgrove, 2001). Stocks of trout and salmon have declined in recent years. This decline in the range of Atlantic salmon and sea trout stocks across Europe in recent years has been matched by a similar recruitment failure in populations of *M. margaritifera* (Young *et al.*, 2000).
- 2.7** Climate change – pearl mussel populations may be vulnerable to climate change through increases in temperatures (it is a cold water species) and through changes in rainfall resulting in a sequence of higher water levels and flooding followed by low water levels and channel bed exposure. Such a sequence may result in individuals been washed out and stranded during floods followed by individuals been stranded in situ when the channel bed becomes exposed during low flow. Another consequence of low flow is that it exasperates the problem with pollutants particularly siltation and eutrophication.

3 Current Action

- 3.1** Statutory site designation plays an important part in the conservation of *M. margaritifera*. In 1992, the EC adopted the *Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora*, known as the ‘Habitats Directive’. The Habitats Directive requires member states to designate and manage Special Areas of Conservation (SACs) for selected habitats (listed in Annex 1 of the Directive) and species (listed in Annex 2). A small proportion of these habitats and species, which are considered most in need of conservation at a European level, are given priority status. The UK has listed 26 candidate Special Areas of Conservation (cSACs) for the Annex II species *M. margaritifera*. In Northern Ireland, three cSACs, the Cladagh (Swanlinbar) River, the Owenkillew River and the Upper Ballinderry River identified *M. margaritifera* as a cSAC selection feature.
- 3.2** At 31st March 2004, three Areas of Special Scientific Interest (ASSIs) designated under the *Nature Conservation and Amenity Lands (Northern Ireland) Order 1985*, identified *M. margaritifera* as a selection feature. These include the sites designated as cSACs, the Cladagh (Swanlinbar) River, the Owenkillew River and the Upper Ballinderry River.
- 3.3** Freshwater mussels have been successfully cultivated in Britain, Europe and in the U.S.A. A restoration project, based at Ballinderry Fish Hatchery, to cultivate *M. margaritifera* in Northern Ireland was initially established by funding from the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) (Preston *et al.*, 2001). Large numbers of Brown Trout were successfully infected with glochidial *M. margaritifera*. These fish were used to culture juvenile *M. margaritifera* ex-situ in large experimental gravel tanks.
- 3.4** The removal of fish from and their reintroduction to rivers requires the authority of a permit issued by DCAL under section 14 of the Fisheries Act (Northern Ireland) 1966, or by the Loughs Agency of the Foyle, Carlingford and Irish Lights commission (FCILC) under similar legislation in the Foyle and Carlingford catchments. Movements of fish onto and from facilities licensed under Section 11 of the Fisheries Act (Northern Ireland) 1966 require authorisation by DARD Fisheries Division.
- 3.5** The cultured population of *M. margaritifera* is being maintained and monitored in the experimental gravel tanks at the Ballinderry Fish Hatchery. This work has been funded by the Environment and Heritage Service. The number of *M. margaritifera* currently being maintained is estimated to be in excess of one hundred thousand individuals. It is planned to continue the culturing programme and to harvest juvenile

mussels for future reintroduction programmes. A similar culturing programme is currently being undertaken in Scotland by the Life in UK Rivers Project.

- 3.6** Water quality is essential to the maintenance and conservation of suitable *M. margaritifera* habitats. In Northern Ireland, water quality is governed by a number of regulations, including the *Pollution of Waters by Dangerous Substances Regulation, 1990*, the *Environment (Northern Ireland) Order, 2002*, the *Pollution Prevention and Control Regulations (Northern Ireland), 2003* and the *Urban Waste Water Treatment Regulations (Northern Ireland), 1995*.
- 3.7** EC Directive 2000/60/EC, *Establishing a Framework for Community Action in the Field of Water Policy* or the Water Framework Directive (WFD), was transposed into Northern Ireland law by the *Water Environment (WFD) Regulations (Northern Ireland) 2003*. The WFD sets a framework for comprehensive management of water resources in the European Community, within a common approach and with common objectives, principles and basic measures. It will be the driving force behind the setting of acceptable water quality standards on which all naturally occurring standing waters depend for the maintenance of their ecological integrity.
- 3.8** The WFD aims to determine baseline trophic ecological states for all surface and groundwaters. The description of Ecological Status will include trophic status. Reference conditions will be agreed to define Good Ecological Status. by setting reference conditions for each type of lake that indicate Good Ecological Status for all waterbody types. Under the WFD, member states must ensure that all waterbodies [(excluding Artificial Waterbodies, (e.g. Northern Ireland canals) and Heavily Modified Waterbodies (e.g. some Northern Ireland reservoirs)] must be at least of Good Ecological Status by 2015. Artificial and heavily modified waterbodies must attain Good Ecological Potential by this date.
- 3.9** There is a requirement under Article 6 of the WFD to create a register of all areas which have been designated as requiring special protection under specific European Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water. protected sites dependent on water within river basin management plans (RBMP) by 2005. Northern Ireland must achieve compliance with the WFD standards and objectives relating to these protected areas by December 2015. There is an onus on the UK government under the WFD to ensure that any changes in water quantity and quality do not adversely affect sites of international importance. Other EU Directives that are currently concerned with water quality will eventually be subsumed into the WFD.
- 3.10** The Rivers Agency, as the statutory Drainage and Flood protection Authority for Northern Ireland, are responsible for maintaining the effective drainage function of 6850 km of designated watercourses under the *Drainage (Northern Ireland) Order*

1973. All drainage and flood defence proposals are subject to the *Drainage (Environmental Assessment) Regulations (Northern Ireland) 1991*, as amended, which require an assessment at planning stage of the environmental impact of the proposed works. Rivers Agency also consults with EHS on their annual programme of drainage maintenance, where this may have an impact on designated sites of nature conservation importance. This includes both localised operations such as the maintenance of outfalls for field drains and more significant river maintenance work. All of these operations can have adverse effects on *M. margaritifera* populations if not carefully planned and implemented.

- 3.11** DARD, through its Countryside Management Branch (CMB), has developed a series of agri-environment schemes including the Environmentally Sensitive Area (ESA) Scheme (revised in 2003) and the Countryside Management Scheme (CMS). Their objective is to protect and enhance semi-natural habitats by encouraging more sensitive management practices. Both these schemes are voluntary and apply to the whole farm. These schemes financially reward farmers who undertake management above Cross Compliance and Good Farming Practice requirements to enhance biodiversity, water quality, landscape and heritage features on the farm.
- 3.12** Forest Service managed areas and grant-aided woodland must comply with the UK Forestry Standard, the government's approach to sustainable forestry ((Forestry Commission & Department of Agriculture for Northern Ireland, 1998)). Field practices must closely adhere to recommendations described in Forest and Water guidelines (4th edition), which is considered a pre-requisite of sustainable forestry in water catchment areas.
- 3.13** The UK Woodland Assurance Standard (UKWAS Steering Group, 2000) is a voluntary certification standard against which current standards of forest management can be measured. The Forest Service has retained certification since 2000. One requirement of the Standard is that management is sensitive to local biodiversity interests, which may be rare or threatened species. Conservation objectives have been produced for all statutory sites designated for their *M. margaritifera* interest.
- 3.14** An EU LIFE Project entitled Life in UK Rivers has developed methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites. This includes reports on the ecology, monitoring and captive breeding techniques of *M. margaritifera* and on their relationship with salmonids (Skinner *et al.*, 2003; Young *et al.*, 2003; Hastie & Young, 2003a; Hastie & Young, 2003b). The reports include details on specific habitat requirements and monitoring protocols for *M. margaritifera*.

4. Action Plan Targets.

- 4.1 Maintain the size of the 3 existing significant populations of *M. margaritifera*
- 4.2 Maintain the range of existing populations of *M. margaritifera* at 7 10km² squares.
- 4.3 By 2010, increase the size of each of the 3 populations above by 50%.
- 4.4 By 2015, re-establish a population of *M. margaritifera* in one former known locality for the species.
- 4.5 By 2020, re-establish a population of *M. margaritifera* in a further suitable site.

5. Proposed Actions with Lead Agencies

5.1 Policy and legislation

- 5.1.1 By 2006, review and if necessary, increase the level of protection given to *M. margaritifera* in the Wildlife (Northern Ireland) Order.
(ACTION: EHS, DOE).
- 5.1.2 By 2010, develop a restocking and reintroduction policy and strategy to stabilise and support and where possible increase existing *M. margaritifera* populations.
(ACTION: EHS)
- 5.1.3 Ensure that *M. margaritifera* sites are properly recognised within River Basin Management Plans by 2009 as required by the Water Framework Directive.
(ACTION: EHS)

5.2 Site safeguard and management

- 5.2.1 By 2008, consider expanding appropriate designations to include tributaries that include or feed sections of river with significant populations of *M. margaritifera*.
(ACTION: EHS).
- 5.2.2 By 2008, begin measures to secure favourable management on sites prioritised as result of 5.6.3 according to agreed timescales.
(ACTION: EHS, DARD, Forest Service)

- 5.2.3 By 2008, secure favourable management of the riparian zone, for example, the creation of fenced buffer strips along river banks that protect river margins from the physical impacts of wading livestock (erosion, trampling and pollution), where appropriate.
(ACTION: EHS, DARD)

5.3 Species safeguard and management

- 5.3.1 Continue existing culturing programmes to ensure further successful recruitment of *M. margaritifera*.
(ACTION: EHS).
- 5.3.2 By 2006, promote the uptake of long-term management agreements with landowners and occupiers of statutory designated sites aimed at creating or maintaining favourable condition.
(ACTION: EHS, DARD, Forest Service)

5.4 Advisory

- 5.4.1 By 2006, provide advice to land owners with *M. margaritifera* on their land about suitable management requirements of the species.
(ACTION: EHS, DARD)
- 5.4.2 By 2006, ensure that information on *M. margaritifera* in Northern Ireland is available to all those who could play a role in its conservation and recovery.
(ACTION: EHS, DARD)
- 5.4.3 By 2007, consider the development of river corridor management skills through training.
(ACTION: DARD, Rivers Agency, EHS).

5.5 International

- 5.5.1 Further develop links with the Republic of Ireland and other European and international organisations and programmes such as the European Environment Agency and the European Centre for Nature Conservation, to promote the exchange of information and experience in research, management techniques, education and conservation strategies.
(ACTION: EHS)

5.6 Future research and monitoring.

- 5.6.1 By 2006, monitor water quality, river habitat and the status of mussel populations.
(ACTION: EHS).

5.6.2 By 2007, develop a 'model river system' to monitor the effectiveness of releasing infected salmonids.

(ACTION: EHS)

5.6.3 By 2007, identify and prioritise sites where *M. margaritifera* restoration and re-introduction may be considered.

(ACTION: EHS)

5.6.4 By 2010, establish appropriate culturing programmes for the introduction and re-establishment of populations in suitable rivers.

(ACTION: EHS)

5.7 Communications and publicity.

5.7.1 By 2008, produce information for the public and schools which explains the conservation importance of *M. margaritifera* in Northern Ireland.

(ACTION: EHS, DENI, DARD)

5.7.2 By 2007, establish a regular workshop on *M. margaritifera* for the exchange of ideas and current information on the status of *M. margaritifera*, water quality and river management issues.

(ACTION: EHS).

5.8 Links with other action plans

5.8.1 Existing populations of *M. margaritifera* are frequently associated with beds of stream water crowfoot *Ranunculus penicillatus*. Both a UK and Northern Ireland habitat action plan for Crowfoot rivers are being considered and these should be particularly pertinent to pearl mussel conservation and future management.

5.8.2 Any future species action plans produced for Atlantic salmon could be especially relevant to *M. margaritifera* reproductive success and recruitment.

6. Costings

6.1 A table showing the global costs for this and other SAPs is available on the EHS web page. (www.ehsni.gov.uk)

7. References

- Araujo, R. & Ramos, M. A. (2001). Action Plan for *Margaritifera margaritifera*. Council of Europe. T-PVS (2000) 10. Strasbourg, 38 pp.
- Bauer G. (1992). "Variation in the life span and size of the fresh water pearl mussel." *Journal of Animal Ecology* 61: 425-436.
- Beasley C.R. & Roberts D. (1996a). "The current distribution and status of the freshwater pearl mussel *Margaritifera margaritifera* L. 1758 in north-west Ireland." *Aquatic conservation: Marine and Freshwater Ecosystems*. 6: 169-177.
- Beasley C.R. & Roberts D. (1996b). Survey of the distribution of the freshwater pearl mussels *Margaritifera margaritifera* L. in Northern Ireland. Unpublished Report to the Environment & Heritage Service (DoE, Northern Ireland).
- Beasley C.R., Roberts D. & Mackie T.G. (1998). "Does the freshwater pearl mussel *Margaritifera margaritifera* L., face extinction in Northern Ireland?" *Aquatic Conservation: Marine and Freshwater Ecosystems* 8: 265 - 272.
- Beasley, C.R. & Roberts, D. (1999). Towards a strategy for the conservation of the freshwater pearl mussel *Margaritifera margaritifera* in County Donegal, Ireland. *Biological Conservation* 89, 275 - 284.
- Chesney, H. C. G., Oliver, P.G. & Davis, G.M. (1993). *Margaritifera durrovensis* Phillips, 1928: Taxonomic status, ecology and conservation. *Journal of Conchology*, 34, 267-299.
- Cosgrove, P., Hastie, L., & Young, M. (2000). Freshwater Pearl Mussels in peril. *British Wildlife*. pp. 340 - 347.
- Costello M.J., Moorkens E.A., Larkin M., Kurz I., & Dowse J. (1998). "Management priorities for the River Nore (Ireland) to conserve the pearl mussel *Margaritifera durrovensis* Phillips, 1928." *Journal of Conchology Special Publication* 2: 257-264.
- Forestry Commission. (2003). *Forest and Water Guidelines*. Fourth Edition. Forestry Commission. Edinburgh
- Forestry Commission & the Department of Agriculture for Northern Ireland. (1998). *The UK Forestry Standard: The Government's Approach to Sustainable Forestry*. Forestry Commission, Edinburgh

- Harris, W. (1744). The ancient and present state of the County of Down.
- Hastie, L.C. & Young, M.R. (2003a). Conservation of the Freshwater Pearl Mussel 1: Captive Breeding Techniques. Conserving Natura 2000 Rivers Conservation Techniques Series No. 2. English Nature, Peterborough.
- Hastie, L.C. & Young, M.R. (2003b). Conservation of the Freshwater Pearl Mussel 2: Relationship with Salmonids. Conserving Natura 2000 Rivers Conservation Techniques Series No. 3. English Nature, Peterborough.
- Hastie, L.C., Young, M.R., Boon, P.J., Cosgorve, P.J. & Henninger, B. (2000) Size, densities and age structures of Scottish *Margaritifera margaritifera* populations. Aquatic Conservation: Marine and Freshwater Ecosystems 10: 229-247.
- Kelso, B.H.L. (1995). The distribution and conservation of *Margaritifera margaritifera* in the Ballinderry river system. Unpublished honours project. The Queen's University of Belfast.
- Lucey, J. (1993). The distribution of *Margaritifera margaritifera* (L.) in southern Irish rivers and streams. *Journal of Conchology* 34: 301 - 310.
- Mackie T.G. (1992). The distribution and current status of *Margaritifera margaritifera* in the North of Ireland. Unpublished MSc thesis, The Queens University of Belfast.
- Mackie T.G. & Hale P.R. (1995). The extent and perceived threats to a freshwater pearl mussel (*Margaritifera margaritifera*) colony in the Broughderg River tributary of the Owenkillew River, Co. Tyrone. Unpublished confidential report to the Environment Service (DoE, N.I.): 24pp.
- Moorkens, E.A. (1999). Conservation management of the freshwater pearl mussel *Margaritifera margaritifera*. Part 1: Biology of the species and its present situation in Ireland. *Irish Wildlife Manuals*, No. 8. Duchas, The Heritage Service, Dublin. 34 pp.
- O'Loan, B. (1997). The status of *M. margaritifera* in the Swanlinbar river, Co. Fermanagh and the effect of environmental variables on its distribution and abundance. Unpublished MSc Thesis, The Queen's University of Belfast.
- Preston, S.J. & Mathers, R.G. (1997). Survey assessment and site boundary delineation of conservation sites on rivers on rivers in Northern Ireland. Unpublished report to the Environment & Heritage Service, (DoE, Northern Ireland).

- Preston, S.J. & Stone, R. E. (1998). Survey assessment and site boundary delineation of conservation sites on rivers on rivers in Northern Ireland. Unpublished report to the Environment & Heritage Service, (DoE, Northern Ireland).
- Preston, S.J. & Muise, E. (2000). Survey assessment and site boundary delineation of conservation sites on rivers on rivers in Northern Ireland. Unpublished report to the Environment & Heritage Service, (DoE, Northern Ireland).
- Preston, S.J., Roberts, D. & Portig, A.A. (2001). Culturing freshwater pearl mussel *Margaritifera margaritifera* in Northern Ireland. A first step towards the reintroduction of a threatened species. Unpublished report to the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER).
- Redding, Sir R., (1693). 'A letter from Sir R. Redding late fellow of the R.S. concerning pearl fishing in the north of Ireland', *Philosophical Transactions of the Royal Society, London*, 17, 659-664.
- Roberts, D., Mackie, T.G. & Ross, H.C.G. (1991). Pilot survey of the freshwater pearl mussel populations of Northern Ireland. Unpublished Report to the Environment & Heritage Service (DoE, Northern Ireland).
- Roberts, D. & Preston, S.J. (2001). Conservation status of the freshwater pearl mussel in the north of Ireland. *Die Flussperlmuschel in Europa: Bestandssituation und Schutzmassnahmen*. Ergebnisse des Kongresses vom 16.-18.10.2000 in Hof.
- Skinner, A., Young, M. & Hastie, L. (2003). Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers Ecology Series No. 2. English Nature, Peterborough.
- Thompson, W. (1841). 'Catalogue of the land and freshwater Mollusca of Ireland', *Annals and Magazine of Natural History*, 6, 16 - 208.
- UK Biodiversity Steering Group. (1995). *Biodiversity: the UK Steering Group Report, Vol 2*. HMSO, London.
- Valovirta I. (1990). "Conservation of *Margaritifera margaritifera* in Finland." *Environmental Encounters*, Council of Europe 10: 59-63.
- Went, A.E.J. (1947). 'Notes on Irish Pearls'. *The Irish Naturalists Journal*, 9, 41-45.

- Williams, A.C. (1997). The status and conservation of freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus) in the Swanlinbar river, Co. Fermanagh. Unpublished MSc Thesis. The Queen's University of Belfast.
- Young, M.R., Cosgrove, P.J. & Hastie, L.C. (2000) The extent of, and causes for, the decline of a highly threatened naiad: *Margaritifera margaritifera*. In: Bauer, G. and Wachtler, K. (eds) Ecology and Evolutionary Biology of Freshwater Mussels Unionoidea. Springer-Verlag, Heidelberg.
- Young, M.R., Hastie, L.C. & al-Mousawi, B. (2001). *Die Flussperlmuschel in Europa: Bestandssituation und Schutzmassnahmen*. Ergebnisse des Kongresses vom 16.-18.10.2000 in Hof.
- Young, M.R., Hasties, L.C. & Cooksley, S.L. (2003). Monitoring the Freshwater Pearl Mussel, *Margaritifera margaritifera*. Conserving Natura 2000 Rivers Monitoring Series No. 2. English Nature, Peterborough.
- Ziuganov V., Zotin A., Nezhlin L., & Tretiakov V. (1994). "The fresh water pearl mussels and their relationships with salmonid fish." VNIRO, Russian Federal Research Institute of Fisheries and Oceanography, Moscow: 104.

List of Useful Acronyms

ASSI	Area of Special Scientific Interest
BAP	Biodiversity Action Plan
CEDaR	Centre for Environmental Data and Recording
CMD	Countryside Management Division
CMS	Countryside Management Scheme
DARD	Department of Agricultural and Rural Development
DCAL	Department of Culture, Arts and Leisure
DETI	Department of Enterprise, Trade and Industry
DOE	Department of the Environment
DRD	Department for Regional Development
EHS	Environment and Heritage Service
ESA	Environmentally Sensitive Area
ESCRs	Earth Science Conservation Review Site
HAP	Habitat Action Plan
JNCC	Joint Nature Conservation Committee
MAGNI	The National Museums and Galleries of Northern Ireland
NESA	New Environmentally Sensitive Area
NIBG	Northern Ireland Biodiversity Group
NICS	Northern Ireland Countryside Survey
NNR	National Nature Reserve
PPS	Planning Policy Statement
RA	Rivers Agency
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SLNCI	Sites of Local Nature Conservation Importance
SoCC	Species of Conservation Concern
SPA	Special Protection Area
WFD	Water Framework Directive
WWT	Wildfowl and Wetlands Trust
UWT	Ulster Wildlife Trust