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Ecological Impact Assessment (EcIA) of The Effects of Statutory Arterial Drainage Maintenance Activities on Three Lamprey species (*Lampetra planeri* Bloch, *Lampetra fluviatilis* L., and *Petromyzon marinus* L.)

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Disclaimer

Foreword

This Ecological Impact Assessment follows on from the strategic approach outlined in "**Series of Ecological Assessment on Arterial Drainage Maintenance No. 1: Screening of NATURA 2000 Sites for Impacts of Arterial Drainage Maintenance Operations.**"

It examines the impacts of statutory arterial drainage maintenance activities on three lamprey species *(Lampetra planeri* Bloch, *Lampetra fluviatilis* L., and *Petromyzon marinus* L.), outlines measures to mitigate any negative impacts, and possible enhancement opportunities.

Environment Section

Ecological Impact Assessment (EcIA) of the effects of statutory arterial drainage maintenance activities on three lamprey species (*Lampetra planeri* Bloch, *Lampetra fluviatilis* L., and *Petromyzon marinus* L.)

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1. Remit

In 2005 the Office of Public Works Drainage Division commissioned the Central Fisheries Board to undertake a two-year study to examine impacts of OPW's channel maintenance programme on two Habitats Directive Annex II taxonomic groups, the lamprey species and the white-clawed crayfish.

It was envisaged that the programme would undertake field studies and collect pre- and post-maintenance data sets on populations of the target organisms with a view to assessing impacts and identifying mitigation measures.

One of the deliverables from this commission involved the compilation of Ecological Impact Assessments (EcIAs) on each of the target groups. The present document deals with the three lamprey taxa, sea-, river- and brook lamprey. The document is broadly structured in the same manner as earlier EcIAs submitted to OPW and published in its "Series of Ecological Assessments on Arterial Drainage Maintenance".

2. Executive Summary

- Adult lamprey have an active swimming phase, migrating varying distances upriver to find suitable gravelled areas where they spawn

- Juvenile lamprey inhabit areas of sediment deposition and may reside there for a number of years

- The three lamprey species found in Ireland are recognised as Annex II species under the Habitats Directive and Special Areas of Conservation (SACs) have been designated for them

- Some lamprey SACs occur in catchments subject to arterial drainage and ongoing maintenance by the Office of Public Works (OPW)

- Channel maintenance is an ongoing requirement under the1945 Arterial Drainage Act

- Maintenance involves removing features that are or may interfere with the design conveyance of a channel e.g. siltation, instream growth of a range of vegetation types, growth of trees within the channel cross-section

- Siltation occurs primarily along the channel margins in drained channels

- Lamprey have been shown to be widely distributed in channels maintained by OPW, both inside and outside SACs

- Studies below have shown that maintenance in silting areas, including those with *Sparganium erectum*, have the potential to remove large numbers of juvenile lamprey and their habitat from the channel

- Studies below have also shown that lamprey can rapidly colonise newly-created areas of sediment deposition, with sizeable population densities recorded after three years

- One study below did not identify any change in lamprey populations after maintenance. This may be a consequence of implementation of the OPW's 10-point environmental training programme

- A range of mitigation measures are proposed.

- Mitigations include more long- and medium term strategic measures centred on creating a GIS-based platform of knowledge on locations of significant areas of habitat and population of lampreys in individual OPW channels

- A series of operational measures are also proposed

- A bottom line is the potential for maintenance to impact on lamprey, particularly juvenile lamprey, populations and habitat in almost any channel of OPW's arterial drainage scheme networks

3. Introduction

3.1. Historical Background and functions of statutory arterial drainage maintenance

This matter was reviewed, in an Irish context, by King (1996). River channelization programmes are designed primarily to offset flooding of urban and rural areas and to enhance the productive value of agricultural land (Hockin 1985). Channelization is also used to enhance navigation and for the floating of timber. Schoof (1980) quotes a figure of 300,000 km of channel channelized in the USA over a period of 150 years. Brookes (1987) describes the widespread effects of man on river channels in Denmark, to the extent that few 'natural' or unaltered channel segments now exist. A primary aim of channelization in Ireland, where it is generally referred to as arterial drainage, is to enhance the incomes of landholders whose lands are affected by drainage or flooding problems. Other objectives include the provision of employment and flood prevention and drainage of urban areas, public roads and bogs (Howard 1980).

Drainage schemes alter the network of streams and rivers in the affected area to enhance their conveyance capacity. The topography of Ireland, with many mountainous areas around the perimeter and a flat central plain, creates a situation where many rivers discharge to the centre of the country with low-gradient flood plains (O'Flynn 1932, Lynn 1980) and extensive areas of flat and low-lying ground. Gardiner and Radford (1980) reported that 21% of agricultural land in Ireland contained wet mineral soils which required drainage to improve their value and potential. The Q3 or 3-year flood return design criterion in Irish arterial drainage schemes since 1945 reduces flood incidence in the cropping season to one in *circa* 15 years (Ryan 1986).

The first Act of Parliament relating to drainage in Ireland was passed in 1842 and was followed by a number of other Acts up to 1945. A large number of small drainage schemes was carried out under these Acts, but on a piece-meal basis. Many schemes fell into disrepair due to lack of maintenance and some Acts were passed simply to allow for the

refurbishment of derelict schemes (Lynn 1980). Current arterial drainage practice in Ireland is largely regulated by the 1945 Arterial Drainage Act (Eire 1945). The important features of this Act were that (i) schemes were based on a holistic or river catchment basis rather than on the previous segmented approach, (ii) the Office of Public Works became responsible for the design and implementation of schemes, (iii) maintenance was to be carried out by the Office of Public Works and (iv) the cost (of same) to be borne by the County Councils of the counties containing the benefiting land. The first major scheme under this Act was initiated in the Brosna Catchment in 1948. Up to 1980, 34 schemes had been completed, accounting for the improvement of 200,000 ha of lands suffering from water logging and flooding (Lynn *op. cit.*). Ryan (1986) summarised the impacts of the 1945 Act as (i) leading to an end to piecemeal drainage and (ii) the protection of the capital investment by ensuring that maintenance would be carried out on a regular basis to an adequate standard.

Major urban flooding events in the mid 1990's identified limitations in the state's capacity to deal with these issues. The OPW was obligated to carry out channel management on a catchment basis, whereas the flooding events were occurring at particular pinch points. To overcome such legal issues, new legislation was introduced in 1995 permitting OPW to carry out engineering works for flood relief on a localized basis.

3.2 Legal and policy context for this ecological assessment

Since 1990 the Central Fisheries Board (CFB) has been engaged in studies, commissioned by OPW, designed to examine the impact of maintenance processes on fish and the fisheries habitat and to examine the feasibility, conveyance benefit and ecological value of alternative strategies that may be adapted in maintenance. These studies were undertaken under the Environmental Drainage Maintenance (EDM) programme (King 1996, King et al 2000). These developments have occurred at a time of major change in emphasis in regard to environmental protection and land management practises, with greater awareness of the sensitivity of the environment and need to conserve biodiversity. The Habitats Directive and Water Framework Directive, at EU level, and the National Biodiversity Programme have all served to heighten

environmental obligations and have created a framework for organisations to examine the impacts of their work practises on the environment and to comply with guidelines or legal obligations. Conscious of this and of the potential for its (OPW) work practises to impact adversely on the environment of the river corridor, OPW adopted a new suite of channel maintenance practises designed to reduce environmental damage and, where appropriate, to provide habitat enhancement in the course of its river maintenance work. The implementation of this new policy involved training provision to OPW's team of field staff throughout the country based on the experience and findings of the EDM programme. Follow-up involved individual site visits to machine crews (2 persons) and their foreman by CFB. By the end of 2005, circa 70 machine crews had been visited by CFB personnel.

Looking forward, OPW was conscious of the requirements of agencies in working within 'conservation areas' designated by the National Parks and Wildlife Service (NPWS). Such areas might include Special Areas of Conservation (SACs) designated under the Habitats Directive and Special Protection Areas (SPAs) under the Birds Directive as well as areas designated under national legislation. Some of the species listed in Annex II of the Habitats Directive, and thus requiring designation of SACs for their conservation, also enjoy protection under national legislation. While OPW's channel maintenance operations are widely dispersed throughout a large number of catchments it was apparent that the actual works activities, or range of activities, consisted of a suite that was constant in both its intent and its likely impact. In view of this 'repeat nature' OPW considered that any assessment of its ecological impacts, particularly in the context of Annex I habitats and Annex II species of the Habitats Directive, might be addressed by examining each taxon or habitat discretely but in a generic manner. Thus, a series of studies was proposed, as outlined in OPW's Screening Report (Gilligan and Dooley 2007).

3.3 Objective and scope of the study

Within the ambit of the EDM Programme, CFB had begun studies to examine the impacts of maintenance on the Annex II Habitats Directive taxa – the lamprey species and the White-clawed crayfish. The importance of this work was further highlighted when OPW commissioned additional studies to focus on these target groups over a two-year period (2005 – 2007). The deliverables from this project were:

- Compilation of Ecological Impact Assessments (EcIAs) in compliance with Section 31 of the Habitats Regulations of 1997 for the four taxa listed above
- Identification of locations of populations of the species
- Identification of typical habitats
- Identification of cost-effective and practical mitigation measures
- Identification of enhancement measures where feasible and applicable

The background context to this EcIA assessment is as follows:

- OPW continues to have an obligation to maintain channels that now lie within SACs.
- Some of these SACs are designated for species that may be directly impacted by maintenance operations
- A potential difficulty arises in the context of the obligations of National Parks and Wildlife (NPWS) to maintain the favourable ecological status of Annex II species (under the EU Habitats Directive) within SACs with the obligations of OPW (under the Arterial Drainage Act, 1945) to maintain channels in proper hydraulic condition
- The assessment examines the extent of potential geographic impact, range of maintenance activities that may impact on the different life-history stages of the species in question, assesses potential impacts and identifies appropriate channel management strategies that are consistent with conserving the ecological status of the target species

- In the present case, the target species are the three lamprey taxa found in Ireland, the Sea lamprey (*Petromyzon marinus* L.), the River lamprey (*Lampetra fluviatilis* L.) and the Brook lamprey (*Lampetra planeri* Bloch)

A general introduction provides a background to arterial drainage and maintenance in Ireland, along with material on lamprey ecology and recent studies in Ireland on this topic. This is followed by an overview of each of the Special Areas of Conservation (SACs) for which lamprey constitute a qualifying interest.

Findings from focussed impact studies form the basis for the chapter dealing with impacts of maintenance while the contribution on mitigations is informed by direct on-site experience.

4. Special Areas of Conservation

Special Areas of Conservation (SACs) are established by EU member states under the Habitats Directive. These are defined as areas within which the conservation status of the species or habitat, for which the designation is made, is retained at a favourable conservation status. Within the Republic of Ireland, SAC designations are generally made, for an area, in respect of a range of qualifying interests. Thus a geographical area may be delineated as an SAC in respect of a range of habitat types listed in Annex I of the Directive as well as a range of species of plants and animals listed in Annex II.

Those SACs with areal overlaps into OPW arterial drainage schemes are tabulated, with qualifying interests, in the OPW's Screening Report (Gilligan and Dooley 2007). In the case of the lamprey species, a total of 10 SACs have been listed by National Parks and Wildlife Service (NPWS). Seven SACs have been designated for the Brook- and Sea lamprey and six for the River lamprey. Of these totals, four SACs are designated in respect of the three species, two are specific to Brook lamprey and one each to River- and Sea lamprey (Table 1). Aspects of individual SACs, including extent of OPW maintenance activity and knowledge on lamprey status are reviewed below.

Site Code 0297 Lough Corrib: This SAC includes the entire lake as well as a number of tributary catchments. Many of the latter have been arterially drained as part of the Corrib-Clare or Corrib-Headford schemes. Principal of these are the R. Clare and its large tributary channels in the east of the catchment, all of which form part of the OPW's Corrib-Clare Drainage Scheme. A number of smaller channels discharging directly to the lake, including the Black River on the east side and the Oughterard River on the western shore, constitute part of the OPW's Corrib-Headford Drainage Scheme
This SAC is designated in respect of sea-and brook lamprey, among other qualifying interests. Sea lamprey are commonly seen spawning in the waters downstream of the major regulating weir in Galway city. The degree of upstream escapement is not known, although there are some historical and recent anecdotal reports of sightings of adults

passing through the fish pass structures on the Galway weir and of spawning adults. Juvenile lamprey, considered to be brook-, were recorded at numerous sites in the Clare catchment by Byrne et al (2001) during fisheries-based surveys in the mid 1990's. A NPWS-commissioned study of the distribution and status of lamprey in the Corrib catchment (O' Connor 2007) found juvenile lamprey to be present in 49% of 77 sites examined. No juvenile sea lamprey were recorded.

Table 1. Overlap of OPW schemes and Special Areas of Conservation (SACs) for lamprey

SAC ref. no.	Location	Relevant OPW scheme	Brook-	River-	Sea-
297	Lough Corrib	Corrib Clare, - Headford	X		X
343	Castlemaine Harbour	Maine		X	X
685	Lough Ennel	Brosna	X		
1976	Lough Gill	Bonet	X	X	X
2137	Lower River Suir	Carrick-on-Suir Flood Relief	X	X	X
2162	R. Barrow & Nore	Kilkenny Flood Relief	X	X	X
2165	Lwr. R. Shannon	inc. Feale, Deel, Maigue	X	X	X
2171	R. Bandon	Dunmanway Flood Relief	X		
2298	R. Moy	Moy	X		X
2299	R. Boyne & B'kwater	Boyne		X	

Site Code 0343 Castlemaine Harbour: This SAC consists of the intertidal and subtidal waters of Castlemaine Harbour, into which the R. Maine and R. Laune discharge, as well as much of the Laune catchment and tributaries and the R. Maine up to Castlemaine village. Of these, the R. Maine catchment has been subject to extensive arterial drainage works, with consequent maintenance, by OPW. The main stem of the R. Maine is tidal to above Castlemaine. Inflowing channels in the tidal zone are sluiced to prevent backup of water into them with rising tide. This impacts on free access of fish to these channels.

Site Code 0685 Lough Ennell: The SAC consists of the lake itself but does not explicitly include tributary channels. Some segments of some channels lie within the SAC as they lie within a boundary covering a terrestrial box of designated habitat. The principal tributary channels of the lake are included in OPW's Brosna CDS and are subject to maintenance. The lake is an important recreational wild brown trout angling fishery and many of the tributaries function as spawning and nursery grounds for brown trout. Brook lamprey is listed as one of the qualifying interests in this SAC.

Site Code 1976 Lough Gill: This SAC has been designated in respect of all three lamprey taxa. As well as L. Gill, the SAC includes the inflowing R. Bonet upstream to its outfall from Glenade Lake. The Bonet has been arterially drained by OPW, with work being completed in the early 1990's. Maintenance is undertaken annually in the channels included in the scheme. Six sites were examined in the Bonet catchment in 2004 (King and Lehane, unpublished data) for lamprey status. Five of these were main-stem and one was on the R.Shanvaus. Only one site, downstream of Dromahair, yielded juvenile lamprey. A total of 27 juveniles were collected, with several age groups present at this site.

Site Code 2137 Lower River Suir: This SAC covers the main stem upriver to Thurles and many of the larger tributaries. The sole area of OPW activity is at Carrick-on-Suir at the head of the tide, where a flood relief scheme was completed in the early part of this decade. That programme consisted principally of flood wall and embankment construction, with no instream works in the R. Suir and no maintenance requirement in the main channel. A NPWS-commissioned study of the distribution and status of lamprey in the Suir catchment found juvenile lamprey to be present in 77% of the 75 sites examined (O' Connor 2007). That investigation found small numbers of juvenile sea lamprey and of transformed river lamprey. Survey work by CFB identified anadromy of both sea- and river lamprey through Carrick-on-Suir, with adults of both species being

recorded at Clonmel, circa 20 km upstream. Sampling for juvenile lamprey in the R. Suir at Carrick in autumn 2002 recorded both juvenile river/brook and juvenile sea lamprey.

OPW is currently developing a flood relief programme for Clonmel, on the R. Suir. An initial design proposed major inchannel works that would have removed the major sea lamprey spawning habitat in the centre of the town. Fisheries survey work commissioned by OPW, in the context of the proposed flood scheme, identified the importance of this area for sea lamprey spawning and also pointed to the concentrating of spawning effort downstream of major weirs on the R. Suir in the town. The current flood relief works and designs for Clonmel involve a similar strategy to that used in Carrick-on-Suir, with no inchannel works.

It is not considered that OPW maintenance works would impact adversely on the status of lamprey within this SAC. Modifications to the weirs in Clonmel, to accommodate upstream passage of sea lamprey, would be of conservation benefit to this species.

Site Code 2162 River Barrow and Nore: This SAC covers the main stem of the Barrow and Nore as well as major tributaries in both systems. It is designated in respect of the three lamprey taxa. A NPWS-commissioned study of the distribution and status of lamprey in the Barrow catchment has recently been published (King 2006). The sole area of OPW activity is at Kilkenny where a major flood relief scheme was completed in the early part of this decade. That programme consisted of flood wall and embankment construction as well as major instream works of widening and deepening. There will be some on-going maintenance requirement. A substantial degree of sampling was undertaken by CFB, commissioned by OPW, in respect of the Kilkenny City Flood Relief Scheme and its potential impacts on juvenile lamprey populations (King and Lyons, unpublished data). Sampling for juvenile lamprey was undertaken within the bounds of the flood scheme envelope. In addition, sampling was undertaken in two major upstream tributaries to assess potential for downstream drift and re-colonisation (Connor 2006). Some post-scheme appraisal work has been undertaken and will be reviewed below.

Site Code 2165 Lower River Shannon: This large SAC includes the Shannon Estuary and subsets such as the Fergus and Maigue estuaries. The freshwater areas include major channels of the R.Feale, to the west, and the R. Mulkear, east of Limerick. The OPW maintain a large network of sea embankments along the Shannon Estuary, primarily at the eastern end. In addition, maintenance work is undertaken in the Maigue catchment, all of which was arterially drained in the1970's, and in selected areas of the Mulkear catchment, where flood relief schemes were undertaken at Cappamore, on the Mulkear, and on the R. Newport.

O' Connor (2006 a) carried out a catchment-wide survey of juvenile lamprey in the Feale catchment and recorded a low degree of presence – 32% of 56 sites examined. In contrast to other catchment-wide studies, there was a high level of sea lamprey recorded. Of the total of 634 juveniles captured in this survey, 18% were juvenile sea lamprey.

Impacts of OPW's channel maintenance on the SACs and their lamprey would relate primarily to the Feale CDS, the two flood relief schemes in the Mulkear and to impacts of Maigue CDS maintenance on the Maigue estuary.

Site Code 2171 River Bandon: This SAC site was selected in view of the important areas of Alluvial Forest present. Large numbers of juvenile lamprey were recorded in this Alluvial Forest area in the course of survey work for the Dunmanway Flood Relief scheme expedited by the OPW. The SAC was designated for Brook lamprey. The flood relief scheme includes significant areas of embankment rather than extensive inchannel works.

Site Code 2298 River Moy: This SAC encompasses almost all of the main stem and major tributaries of the R. Moy as well as L. Conn and L. Cullin. It is designated for both Sea- and Brook lamprey. The entire catchment was drained as part of the Moy CDS by OPW and ongoing maintenance takes place.

A catchment-wide survey of juvenile lamprey was undertaken in 2004 (O' Connor 2004).

Juvenile lamprey were present at 62% of the 75 sites examined. Juvenile sea lamprey were quite widely recorded and constituted 18% of the total number of juvenile lamprey taken.

Site Code 2299 River Boyne and River Blackwater: This extensive SAC includes much of the main stem of the R. Boyne and R. Blackwater as well as major tributaries. It is designated for River lamprey, only, of the three lamprey species. The Boyne catchment was arterially drained by OPW and that programme encompassed a more substantial area of catchment than the current SAC designation. Ongoing maintenance work is carried out by OPW.

A catchment-wide survey confirmed the presence of significant populations of juvenile lamprey in this catchment (O' Connor 2006 b). Juvenile lamprey were present at 77% of the 87 sites examined. Juvenile sea lamprey were not recorded. Autumn netting in the Boyne estuary by Fisheries Board staff indicated the presence of River lamprey adults and there is an anecdotal report of River lamprey spawning in the Yellow River (C1/8/5). Officers of the Eastern Regional Fisheries Board reported evidence of Sea lamprey spawning activity in the main channel of the R. Boyne near Rosnaree.

A detailed study of OPW maintenance impacts on juvenile lamprey is ongoing by CFB in the R. Stonyford (C1/32) and is discussed in detail below.

5. Maintenance Activities carried out by OPW

The 1945 Arterial Drainage Act deems that channels within drainage schemes should be retained "..in proper repair and effective condition….". In theory, this could mean that maintenance on channels could cause a recovering or naturalising watercourse to revert back to its immediate post-scheme appearance with perfectly-formed trapezoidal cross-section, removal of any instream features or obstructions, removal of any tree growth within the cross-section and bankslopes devoid of plant cover.

Drained channels have extended segments of uniform character and maintenance is intended to retain the hydraulic capacity of channels by removing depositions and obstructions within the cross-section. Sediment transport and deposition can facilitate vegetation growth, both marginal and instream. This growth can, in turn, facilitate a cycle of further silt accretion and plant growth. Such developments can create an elevated water level for a particular flow discharge, increasing the potential for bank overtopping in summer flood conditions. Removal of such obstructions lowers the water surface level for the same volume discharge and serves to facilitate land drainage outfall works. Tree growth within the cross-section can also serve to impede flood flow or create an elevated flow level for a particular volume discharge. Both instream and marginal vegetation, as well as tree cover, contribute to the biodiversity of the river corridor as an ecological unit.

The scale of the OPW's national remit in respect of channel maintenance has been outlined in its Screening Report (Gilligan and Dooley 2007) and includes maintenance work on channels, structures and embankments. The changed climate of environmental awareness, reflected in the series of environmental Directives from the European Union, and major developments in machinery technology have facilitated significant changes in OPW's channel maintenance activities. Coupled with these have been changes away from whole-catchment arterial drainage and the emergence of a senior corps of engineers empowered to work in a partnership type approach, as one of several river corridor

stakeholders, rather than in the older more one-track approach. The requirement for a greater balance between conveyance requirements and river corridor wildlife concerns was a key theme in the training course on environmentally-sensitive work practises delivered to OPW staff in 2002-03.

OPW's three Maintenance Regions generate annual programmes detailing proposed lists of channels scheduled for maintenance. These are finalised and circulated to relevant stakeholders in the first weeks of each year. The programmes contain GIS-based maps as well as the lists, showing clearly the channels, or channel segments proposed for works. These documents form a basis for consultation with major stakeholders, particularly the Regional Fisheries Boards and Divisional staff of the National Parks and Wildlife Service. The consultation facilitates specifying of timescales and windows in respect of particular channels, as well as flagging additional environmental opportunities for 'enhancement' e.g. fisheries instream enhancement work, while maintenance may be underway.

Important elements that inform OPW's current maintenance approach include:

- Replacement of dragline machines with long-reach hydraulic machinery

- Deployment of a fleet of hydraulic excavators, giving drivers full control of the machine bucket at all stages of extension and retrieve

- Bringing specialist excavator 'bolt-ons' into use as these come on-stream – including specialist weed-cutting buckets and tree-management jibs

- Dividing long channels into a series of segments, with successive segments done in annual sequences

- Compliance with environmental windows for working – including salmon and trout spawning windows in winter-spring and bird nesting windows in spring-summer

- Implementation of the ten-point environmentally-sensitive training programme as a Standard Operating Procedure (SOP) in channel maintenance

- Circulation of annual maintenance programmes to key stakeholders

- Regular meetings with key stakeholders to preview scheduled maintenance work

6. Maintenance impacts on life-history stages of lamprey

This chapter is divided into three parts. The first provides a rapid overview of likely impacts on lamprey, given the ecology and life history (Kelly and King 2000; Maitland 2003) and involves terminology used to describe the nature and extent of impact in Environmental Impact studies (IEEM 2006). The second part provides a more detailed commentary on potential maintenance interactions with life stages and the final part presents results from case studies in Irish arterially-drained channels undertaken in the context of this study.

6.1 An overview of potential impacts

Terms in bold below are those used in IEEM (2006) to describe potential impacts in Ecological Impact Assessment studies. Lamprey spawn in gravelled areas and the juvenile phases may spend several years in areas of fine sediment prior to metamorphosing into young adult fish. Maintenance impacts on both habitat types are potentially **negative**, particularly on the latter.

Maintenance work involving desilting, a common feature in such operations, has potential to remove substantial areas of habitat that may be in active use by juvenile lamprey. The operation will, potentially, remove both habitat and occupants and will be of substantial **magnitude** over an **extensive** area in the channel being maintained. The **duration** of impact may also be substantial, as both habitat features and potential occupants are required to redress the initial negative impact.

Timing and **frequency** of maintenance can be managed, with timing commonly being linked to permissible environmental windows. However, in the case of juvenile lamprey there is no optimal timing for maintenance that will involve desilting. Juvenile lamprey may be present in silting habitats at all times of year. Transformation from juvenile to adult occurs in the August – September period and transformers, being active swimmers,

may have some opportunity for escape at this time. However, other age groups would still be present in sediments scheduled for removal.

Spawning commonly occurs in April – May for river- and brook lamprey and in May-June for sea lamprey. Disturbance of gravelled areas in maintenance, even in those cases where the mitigation option of 'gravel loosening' were being implemented, could, during the lamprey spawning season, lead to damage to nesting redds or spawning groups of fish and dispersal of recently fertilized eggs prior to appropriate stage of development.

6.2 River engineering works and lamprey life history stages

Barriers: The majority of lamprey species have similar life cycles. On completion of the adult feeding phase, spawning lamprey migrate upstream to seek out areas of gravel where they can form redds (nests), in which to deposit their eggs, which are then fertilised by male lamprey (Moser *et al.* 2007). The timing of the upstream migration of both the river- (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) varies with latitude, temperature and discharge (Hardisty and Potter 1971). Spawning in river and brook lamprey (*Lampetra planeri*) generally occurs in the early spring. However, the river lamprey can begin the upstream migration from marine waters as early as the previous August. The upstream migration of the anadromous sea lamprey occurs between spring and early summer, one or two months before spawning (Hardisty and Potter 1971). As a result of the variations which exist between the life cycles of the three lamprey species, it is important that the implementation of mitigation strategies reflect these differences.

On the migratory routes of lamprey, there must be no significant obstacles (chemical or physical), if lamprey are to successfully travel from the sea and estuaries to their spawning grounds (Harvey and Cowx 2003). Hydroelectric dams and weirs currently deny lamprey access to many valuable spawning grounds. Significant alteration of

channels that removes resting cover or creates stretches of fast flow (>2 m/s) must also be avoided along the migration route of lamprey. In particular, habitat in stretches used for spawning should retain areas of suitable gravel with interstitial currents that attract nest building (Harvey and Cowx 2003).

Of the three Irish lamprey species it is the sea lamprey which undertakes the most extensive upstream migrations. The brook lamprey is the only Irish species that is non-parasitic and it spends all its life in freshwater (Maitland and Campbell 1992). However, overall, it is believed that the brook lamprey is less affected by river barriers than either the river or sea lamprey (Harvey and Cowx 2003). This is due to the short migrations undertaken by this species - distances travelled are often less than 1km (Hardisty and Potter 1971) - and its ability to complete its life cycle over quite short stretches of river (Harvey and Cowx 2003). The upstream migration into the higher reaches of a catchment allows adult lamprey maximum dispersal to find suitable conditions for spawning. This allows for the slow, continuous downstream movement of larvae into sedimented areas of lower water velocity. Any blockages of these migratory passages can lead to severe decreases in, or indeed the eradication of, populations.

Weirs and other such works as croys and groynes also render rivers unsuitable for the migratory ascent of lamprey (Applegate 1950; Harvey and Cowx 2003). When faced with barriers, lamprey exhibit sustained exploratory movements, passing backwards and forwards along the surface in search of a passage (Hardisty and Potter 1971). According to Applegate (1950), lamprey are able to pass quite high weirs or falls by a series of intermittent and violent wriggling movements, although they seldom ‘jump’ more than 600mm vertically. Igoe *et al.* (2004) also describe valiant efforts of sea lamprey to ascend barriers in the R. Mulkear catchment. It is important that channels be kept free of obstacles that may impede the upward movement of lamprey. Trees and other major debris can be washed downstream in floods and collect on weirs. Accumulations of debris can lead to vegetation growth and the ability of the weir to pass adult lamprey may be further impeded. Periodic cleaning of these structures is necessary. If maintenance is scheduled for a lamprey SAC/OPW channel it would be appropriate for Fisheries Board

personnel and OPW personnel to examine the weir(s) and its shortcomings with a view to the potential for ameliorative measures to be implemented. The impact of the obstruction may be exacerbated in conditions of low flow, which could result in significant losses to the spawning run.

Of less dramatic appearance, but equal impact, are barriers created by bridge sills and apron structures. These may pass such thin films of water in low flow as to prevent fish passage. The design level of bridge floors is not always smoothly aligned with the up- and downsteam channel segments. This can create vertical barriers that may be impassable to lamprey. Such localised structures may be particularly significant for the very small brook lamprey. This facet is also of relevance to OPW in terms of the stability of the structure. Such downcutting frequently leads to an undermining and subsequent collapse of part of these apron structures. Remedial work, if using large quantities of rock armour to fill voids and dissipate the fluid forces, can also facilitate fish passage in these situations.

The conditions for passage can be related to volume discharge. River lamprey migrate in autumn-winter in times of high flows and can pass weirs and barriers that are impassable in low flow. Sea lampreys migrate to spawn in the May-June period when flows are often at low or falling levels. This can create even greater problems for this species. It is evident from Irish data and from continental research that sea lamprey populations are frequently focussed into the downstream reaches of major channels, even when extensive areas of suitable habitat for spawning and nursery use are available for long distances upstream. This focussing is due to an inability to pass weirs and other major barriers. Such focussing has a major adverse impact on the conservation status of sea lamprey, in particular, and opportunities to modify fish passage, either in the course of maintenance or in capital works projects, should be availed of with a view to enhancing the species' status.

Suspended Solids: Suspended solids generated in maintenance are not likely to impact adversely on adult lamprey entering the lower reaches of a system. However, as the fish ascend into a discrete channel any maintenance work in that channel may cause disturbance. This would be particularly the case in situations of low flow. In OPW maintenance sites the channel is generally running clear some hours after completion of work each day, as working hours generally span from circa 08.30 hours to 16.30 hours (Gilligan and Dooley 2007). In addition, maintenance is not carried out at weekends. These breaks provide clear-water windows for adult lamprey to pass through areas of maintenance work.

Disturbance of gravels during spawning intra-gravel life phase: Adult lamprey lay their eggs in nests that they build in gravel. After a time the eggs hatch and the young drift downstream to areas of silt in which they burrow. The intra-gravel phase is relatively short and only lasts for 3-4 weeks. Any disturbance to the gravels by machinery at this stage would have detrimental effects on the specific year class.

The egg and post-egg stages are gravel-bed/nesting site-associated and are dependent on water, passing through the gravel bed, to permit gaseous exchange and removal of waste metabolites. Any diminution of the rate of exchange, permitted through the passing water, could be deleterious to the young life stages. Some filling of the interstices in the gravel mound will occur naturally over time and as the young are still developing. However, this natural process could be augmented by the creation of additional silt or particulate loads from upstream created by a channel maintenance operation. Such actions should not be taking place in a lamprey spawning channel at this time of year, as indicated above. A moratorium on maintenance during this period would provide a mitigation measure eliminating any potential for adverse impact from maintenance during this time.

Disturbance of juvenile or nursery habitat: Once hatched, juvenile lamprey move downstream into areas of soft sediment. In these silt patches lamprey burrow and filter-

feed. Juveniles can remain in these sediment patches for anywhere between three and seven years. It is at this stage in their lifecycle that lamprey are particularly vulnerable during maintenance. Due to the hydrological features of rivers, deposition of sediment typically occurs laterally on straight segments and on the inner sides of bends or meanders. It is in these marginal habitats along river channels that juvenile lamprey are generally found. Maintenance routinely involves the removal of large amounts of sediment from the channel along with the marginal vegetation, which can result in major losses of the resident lamprey population and its habitat. Upon removal from the channels, ammocoetes are left vulnerable on spoil heaps where they become easy prey for birds or are vulnerable to desiccation. The removal of silt from the channels also reduces the amount of available habitat for newly hatched lamprey recruiting to the population.

6.3 Case Histories of OPW channel works/maintenance impacts on lamprey

6.3.1 Case History I: C1/32 (Boyne CDS) R. Stonyford

Lamprey sampling enclosure, R. Stonyford

18 enclosures, each of one metre square, were set up along a 300 m section of channel that was identified as containing substantial areas of optimal lamprey habitat and these were quantitatively fished prior to maintenance. Approximately seven weeks after maintenance had been completed, post maintenance electric fishings were carried out in the same pre maintenance enclosures.

The post maintenance population sampled on this channel was less than 20% of the pre maintenance population. However, the length structure was spread across the entire size range of the pre maintenance lamprey sample (Figure 1). No significant differences existed between lamprey lengths i.e. population structure, sampled pre- and post maintenance surveys.

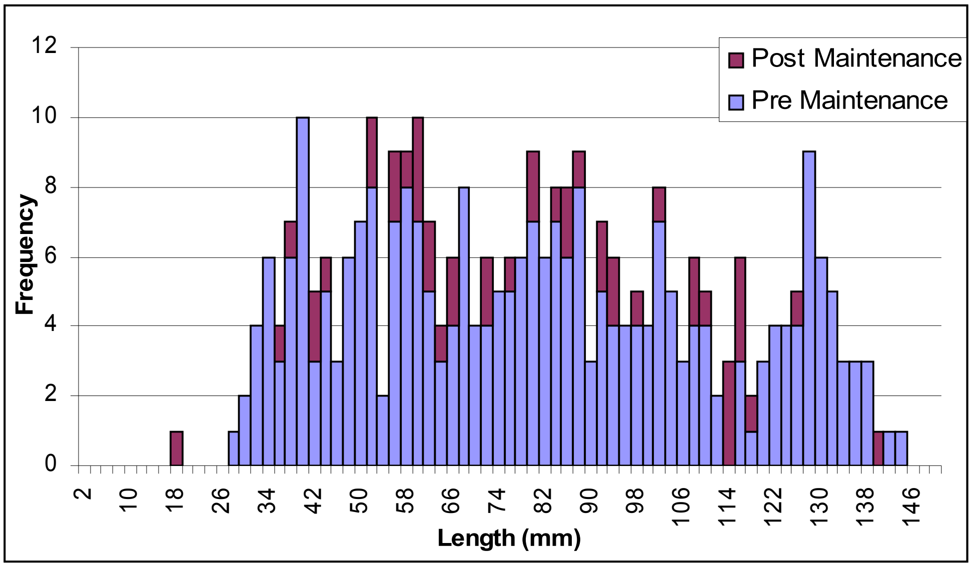


Figure 1. Pre (N = 265) and post (N = 46) maintenance length frequency of lamprey sampled on the C1/32 Boyne.

In all sites, except site 8, pre maintenance densities were higher than post maintenance densities (Figure 2). In 5 of the post maintenance sites, no lamprey were observed. Confidence intervals of zero were associated with a number of the post maintenance fishings, due to the low or zero number of lamprey encountered. Statistical analysis (Wilcoxon-matched pairs test) revealed that significant differences existed between the pre and post maintenance densities ($n = 17$, $t = 0$, $p<0.05$).

As this was a focussed study, the maintenance crew were required to deliberately target areas of sediment deposition, including all areas where quantitative sampling had been carried out. This process ensured a maximum impact on the juvenile lamprey habitat and occupants, with a view to assessing scale of such impact. The findings indicate the degree of potential negative impact from conventional bucket use in maintenance.

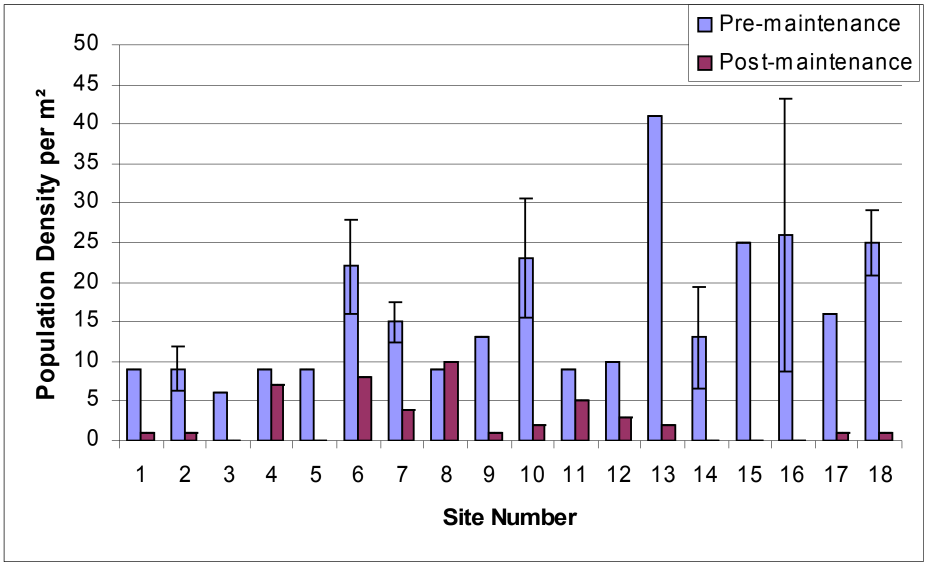


Figure 2. Population estimates with associated 95% confidence intervals for pre and post maintenance electric fishings on the R. Stonyford.

6.3.2 Case History II: C1/37 (Boyne CDS) R. Deel

A study of eight enclosures (1 m^2), spread over several kilometres on the C1/37 Boyne, showed that there were no significant differences between the pre- (2004) and post- (2005) maintenance population structures or densities at the eight locations examined. The apparent absence of impacts on juvenile lamprey may be due, in part, to the implementation of OPW's environmentally sensitive maintenance protocol, insofar as all enclosures were adjacent to the water's edge and some may have been situated on the non-working side of the channel. A site visit with the Civil Foreman to the driver crew on the R. Deel in 2004, while maintenance was underway, identified a strong compliance with the new environmental protocol of OPW.

The length frequency data indicated little change in the overall population structure of ammocoetes in the year after maintenance (Figure 3) and significant differences were not detected between the two population structures.

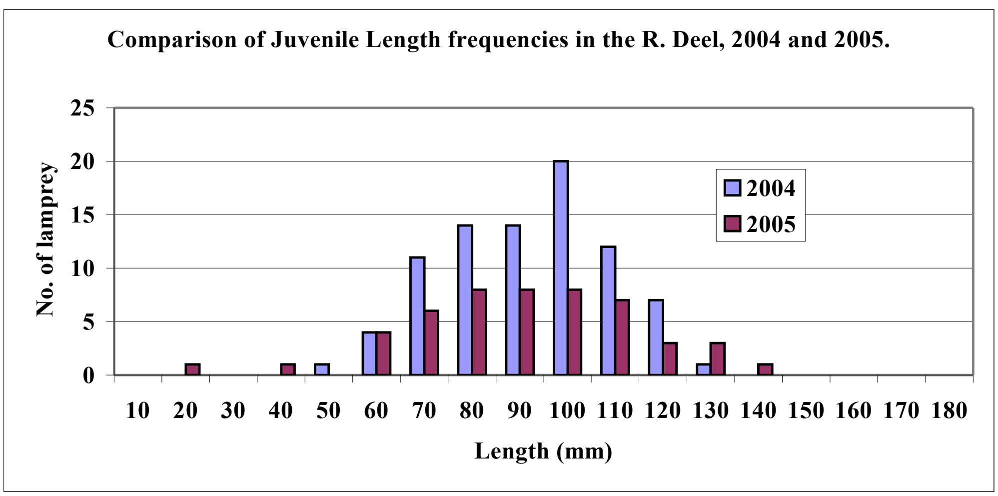


Figure 3.3.3 1 R. Deel (C1/37, Boyne CDS) ammocoete length frequency

Figure 3. River Deel (C1/37 Boyne) Ammocoete length frequency pre (2004) and post maintenance (2005) based on 8 sampling sites.

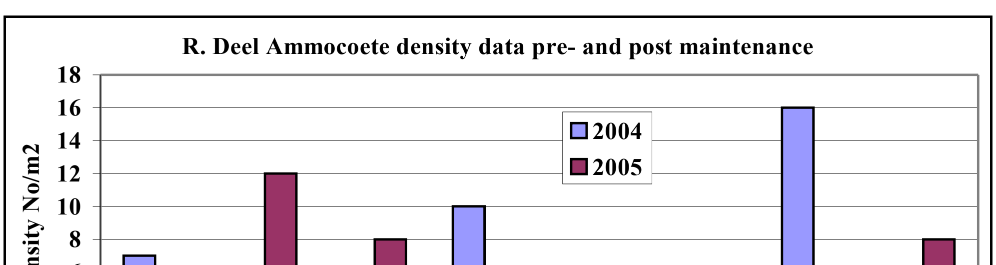


Figure 3.3.3 1 R. Deel (C1/37, Boyne CDS) ammocoete length frequency

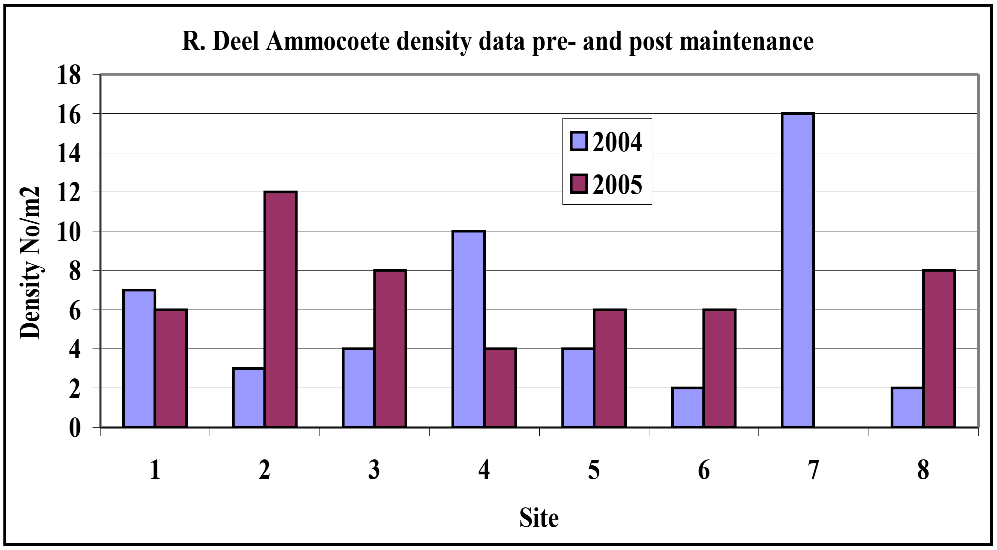


Figure 4. Deel ammocoete density data from eight sampling sites pre (2004 and post maintenance 2005

In five of the eight locations density values were higher in the year following maintenance (Figure 4). However when these were tested statistically no significant differences were detected between the pre and post maintenance densities.

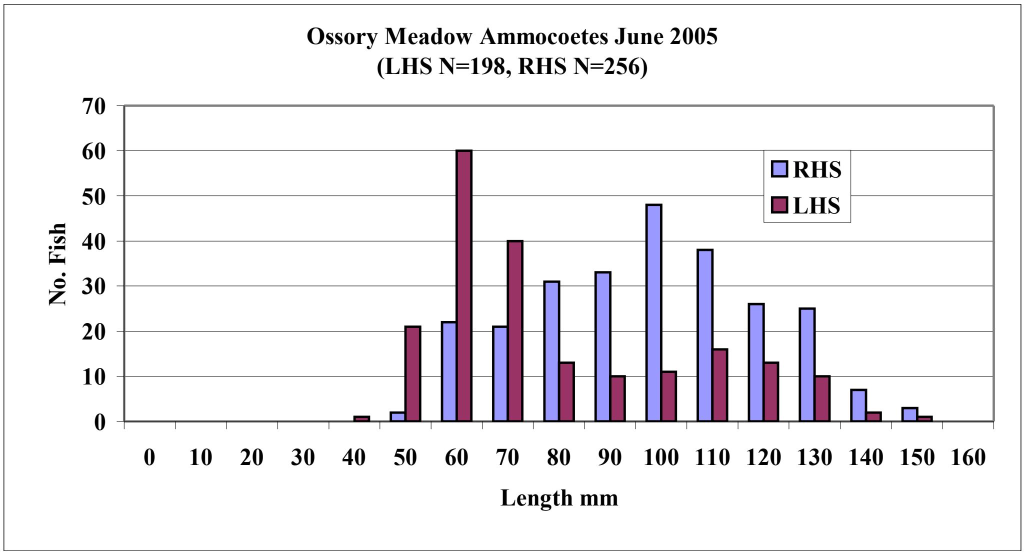
This study was extensive in areal coverage and spread of enclosures, as opposed to the previous Case Study I where all sampling enclosures were in a relatively short segment (circa 300 m) of channel. This may account, in part, for the different outcomes from the two studies. All of the Stonyford enclosures were deliberately impacted whereas there was no such on-site strategy in the case of the Deel. Some of the Deel enclosures may have been on the non-working side of the channel, thereby escaping impact. As stated, there was clear implementation of the 10-point environmental protocol and this, too, may have contributed to the outcome on the Deel.

6.3.3 Case History III: R. Nore - Kilkenny City Flood Relief Scheme at Ossory Meadow

Ossory Meadow on the Kilkenny Flood Relief Scheme

Ten enclosures were examined on each side of the R. Nore main channel at this location. On the newly-created left bank, length frequency data indicated a bimodal distribution (Figure 5). The modal peak of 50 mm was particularly marked, with a lesser modal peak in the 100 – 120 mm range. On the right bank, undisturbed during the works process, ammocoetes ranged in size from 50 to 150 mm, as with the left bank, but the size distribution was unimodal with a peak at 100mm (Figure 5). Significant differences were detected between the two population structures.

The density data spanned a wide range on both sides of the channel (Figure 6). In nine of the ten sites densities taken from the undisturbed right bank were higher than those taken from the recently-created left bank. Significant differences were detected between the densities sampled between the two banks.



and recently-excavated (LHS) sites in Ossory Meadow, R. Nore, June 2005

Figure 5. Comparison of ammocoete length frequency at undisturbed (RHS) and recently- excavated (LHS) sites in Ossory Meadow, R Nore June 2005

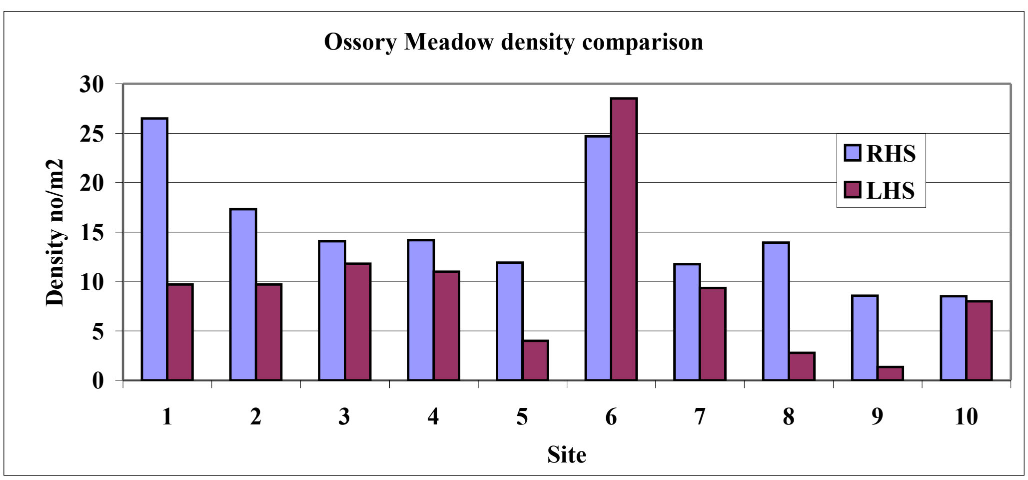


Figure 6. Comparison of density data from newly formed left bank and the undisturbed right bank, Ossory meadow, R. Nore, June 2005.

6.3.4 Case History IV: R. Nore - Kilkenny City Flood Relief Scheme at Duke's Meadow

Duke's Meadow on the Kilkenny Flood Relief Scheme

The results, in relation to population structure and density, showed many similarities to those from Ossory Meadow (Case Study III, above). The newly excavated side (RHS: 10 enclosures) had an ammocoete modal peak at 50mm with a decreasing level of representation of larger length groups (Figure 7). In contrast, the unimpacted side (LHS: 6 enclosures) had a greater number of larger ammocoetes. Significant differences were detectable between the population structures on the left and right hand side banks.

When the density values were initially examined it was clear that the mean density value was substantially higher on the unimpacted side of the channel (Figure 10). However, a high level of deviation about the mean value was observed on both sides of the channel. When tested statistically, significant differences were not detectable between the densities sampled from the left and right banks.

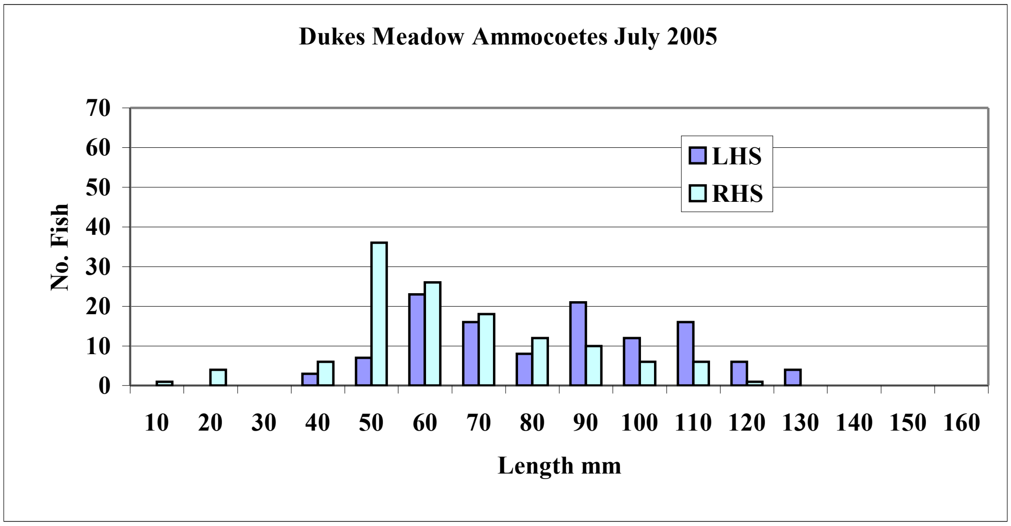
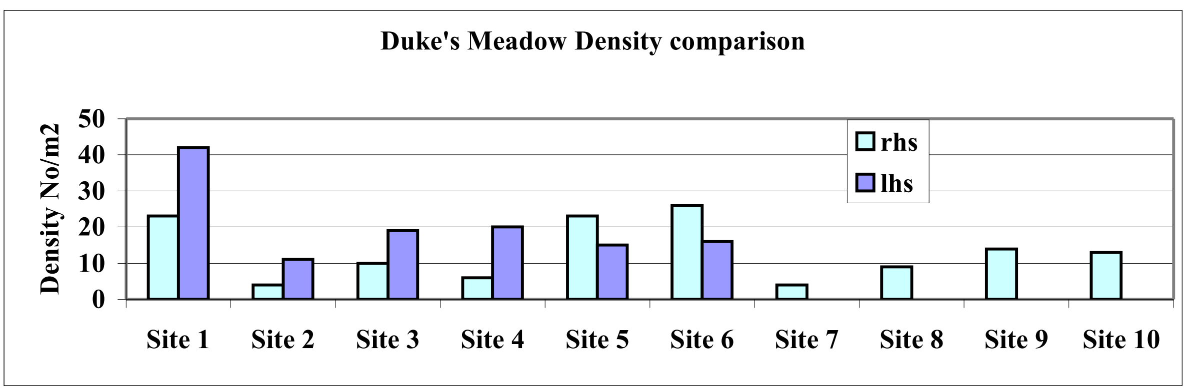


Figure 7. Comparison of ammocoete length frequency at undisturbed (LHS) and recently excavated (RHS) sites in Duke's Meadow, R. Nore, July 2005.

Figure 8. Comparison of density data from newly formed right bank and the undisturbed



left bank, Duke's Meadow, R. Nore, July 2005.

The findings from the two studies on the R. Nore at Kilkenny (Case Study III and IV) are significant in indicating a 'rate' of recolonisation following creation of new habitat. The

Std. Deviation

new habitat areas were terrestrial, dry-land habitats prior to excavation for channel widening within the design requirements for the Kilkenny City Flood Relief Scheme. The excavation works were undertaken and completed in the two zones in 2002. The survey in 2005 is considered indicative of rapid colonization, with a single age group, in each case, being the dominant element in the 'new' populations. The 'new' populations differed significantly in structure from the adjacent 'established' or undisturbed populations. The new populations arose through colonization or downstream drift as well as displacement of upstream lamprey via flooding or torrential flow events.

The rapid establishment of juvenile lamprey in suitable, newly-created habitat, may be seen as having a comparator in channel maintenance, where populations may be lost from the channel entirely or dispersed downstream. If the channel being maintained has a population of juvenile lamprey over its full length and if only part of the overall length is being maintained then downstream colonization may be important in any recovery of the lamprey population in the impacted area following the maintenance event. The modal peak in the new habitat at Ossory Meadow would point to colonization having commenced in 2003, one year after maintenance, by newly-hatched ammocoetes moving to find new habitat in which to burrow and grow.

6.3.5 Case History V: R. Tullamore Silver (C9/1 Brosna CDS)

The Silver River. C9/1 Brosna.

This channel has extensive stretches of low gradient in its lower reaches, with a deep glide character and heavy instream growths of *Sparganium erectum*. This tall emergent plant tends to trap silt at its basal areas. Sampling during a previous maintenance event indicated that juvenile lamprey were present and were being removed in spoil.

The water depth prevented use of electric fishing as a sampling tool and OPW Mechanical Engineering staff in OPW East Region fabricated a suction dredge, to a design developed by a French ecologist, to sample juvenile lamprey at depth. This prototype was trialed in tandem with a quantitative machine bucket method during maintenance on this channel in autumn 2007.

Of relevance in Figure 9 is the size range of juvenile lamprey taken by bucket sampling and the numbers involved. As these were collected as part of the study comparing two potential ‘sampling techniques’ all lamprey measured were returned to the channel,

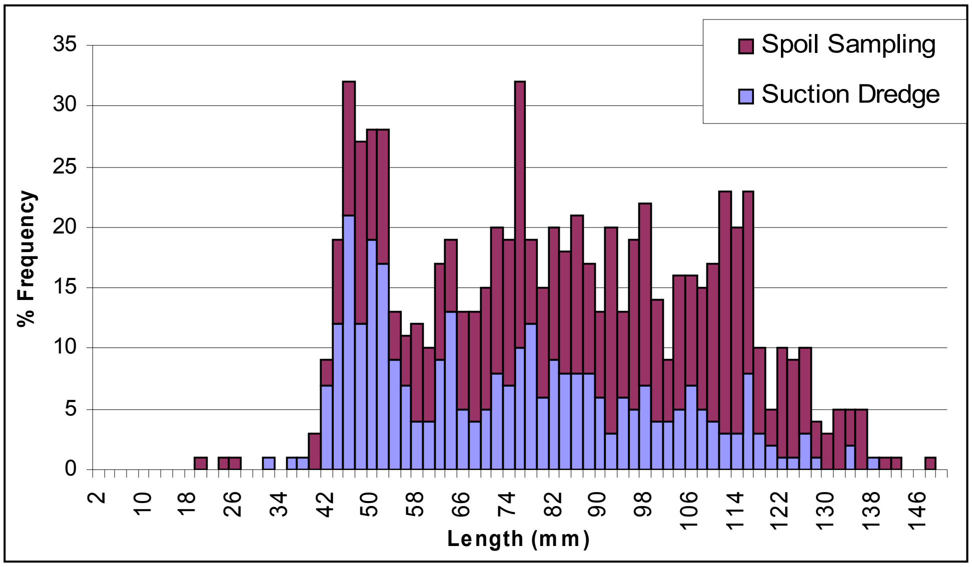


Figure 9. Percentage frequency distribution of lamprey sampled using the suction dredge (N = 311) and bucket samples (N = 455) on the C9(1) Brosna.

downstream of the sampling area. The numbers do give an indication of the scale of potential loss of juvenile lamprey within a routine maintenance operation.

When examined in density terms (Figure 10) it is apparent that losses would range from

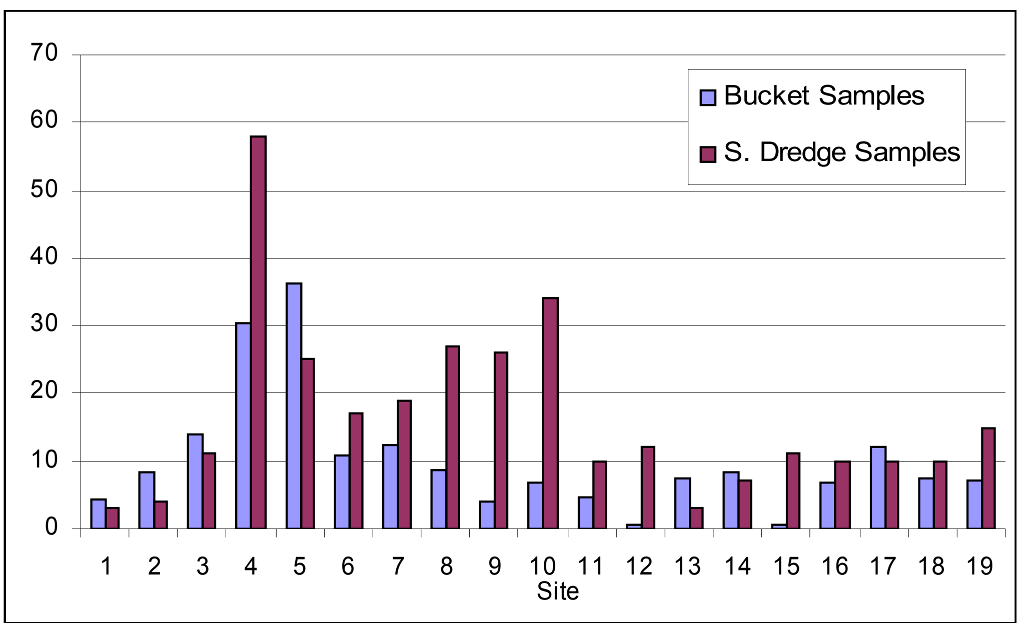


Figure 10. Minimum densities of lamprey sampled using the suction dredge and quantitative bucket sampling on the C9/1 Brosna.

minimum levels of 1 – 2 fish / m^2 to maximum levels of 35 fish /m^2. The majority of density values for excavator bucket sampling lay in the 5 – 10 fish / m^2 category.

The Tullamore Silver identifies the potential scale of loss of juvenile lamprey in a *Sparganium erectum* channel, due to channel maintenance. On the other hand, were maintenance not to occur, or the cycle to be extended, the *Sparganium* stands may become sufficiently silted to the degree that a floral succession could occur, with replacement of *Sparganium* by more ‘terrestrial’ plant species. This succession might ultimately lead to a ‘terrestrialisation’ of the marginal habitat areas and a loss of the areas of siltation. Thus, over an extended period, it is feasible that the maintenance cycle may be permitting retention of some form of ‘intermediate’ ecological stage in the channel that facilitates siltation and, thus, habitat creation for juvenile lamprey. The range of size/age groups present in the Tullamore Silver study sites (Figure 9) indicated a population with a good conservation status, based on Harvey and Cowx (2003).

7. Lamprey Mitigation Measures

It is evident from the previous section that channel maintenance has the potential to impact substantially on both the habitat and populations of lamprey. This is particularly the case for the juvenile life stages resident in areas of sediment deposition as such material is seen as being in the front-line in terms of creating and contributing to creation of channel conveyance impediments.

Studies on catchment-wide distribution and status of juvenile lamprey populations frequently indicate a disparate distribution with a wide dispersal of both presence and of population size where present. This dispersal is commonly unrelated to presence of suitable or, indeed, optimum habitat. Thus the occurrence of substantial areas of juvenile lamprey habitat may not signify the presence of such populations. However, it is considered appropriate that maintenance operations be mindful of the presence of such habitat areas and retain the integrity of such areas.

A series of mitigation measures present themselves. These are listed below and are grouped into Strategic or Operational measures. The Strategic measures require an element of forward planning by OPW. Some of these would require allocation of resources to populate the databases proposed and may only be fully achievable over a period of years. Others would simply require a re-focusing of certain existing planning practices and procedures with OPW's three maintenance regions to incorporate consideration of lamprey issues.

On the Operational front, it is considered that implementation of the 10-point environmental training programme would provide a substantive basis for mitigations. This potential is also recognized in other EcIA documents submitted to OPW. To be effective for lamprey mitigation, the relevant training points would require to be robustly implemented as a standard operating procedure (SOP) in identified lamprey channels – in the context of habitats or populations. A second suite of Operational mitigations emerges

from direct observation of the OPW's machinery in operation and of channel/structures management issues.

7.1 Strategic Measures – medium / longterm planning

- *Lamprey walk-over surveys:* The Scottish Natural Heritage (SNH) has developed a procedure for recording locations of potential spawning habitat (suitable gravelled areas) and areas of potential nursery habitat (areas of fine sediment accumulation) for lamprey along river channels (APEM 2004). This process involves the walking of a channel and mapping areas of both spawning and nursery habitat using a detailed O.S. map and GPS instrument. The up- and downstream extents of sediment areas are noted and recorded via GPS. This permits the data to be loaded into a GIS layer, showing extent of sediment patches and their locations, which can be superimposed onto the OPW channel maintenance layer. The technique allows for both pre- and post maintenance appraisal of the channels. The procedure would identify lamprey sensitivities to OPW well in advance of proposed maintenance. It is not considered that this proposal could be rolled out in a rapid fashion, rather that it could be developed in a focused manner as resources were made available. Initially it might concentrate on channels within SACs, known to harbour juvenile lamprey. The published reports on lamprey distribution in the Irish Wildlife Manuals Series of NPWS might provide a suitable launch platform. The walkover survey process in operation in the EREP study (2008 – 2012) may also provide an opportunity to build up this survey layer.

  Catchment-wide surveys have been undertaken to assess the status and distribution of lamprey. During these surveys assessments have been based on habitats adjacent to bridges or other logistically-feasible access points shown on 1:50,000 maps. However, such habitats may not be generally representative of the entire channel. Using the SNH protocol 'fills in the gaps', so to speak, between bridges and provides a robust appraisal of potential lamprey areas and also the extent of such occurrence along any particular channel segment.

The appraisal must identify the extent to which individual areas of deposition extend out into the open channel flow area from the water's edge or consist of islands in the open channel. Thin ribbons of sediment adjacent to the channel margins might reasonably be avoided via implementation of specific environmental measures espoused in the OPW driver training programme. Large areas of sediment extending out from the bank may require specific attention and may require to be skipped by the machine. Islands of material will normally be removed as these constitute a particular conveyance issue.

- *Assessment of specific sensitivities from SNH mapping:* Identification of potential lamprey habitats should be followed by preliminary electric fishing surveys to determine if lamprey are present or not and if so, in what densities. Given the potential impacts of maintenance on lamprey populations (see 6.3.1 and 6.3.5 above) it is imperative that OPW equip itself with first-hand knowledge on lamprey status and distribution in its network of channels. This is especially so for SAC channels, such as those in the Boyne, Moy, Corrib, Feale. Such an approach would provide OPW with a knowledge base but would also flag specific locations where particular sensitivities would arise and where specific mitigations might be required, in consultation with Fisheries Boards and National Parks and Wildlife Service. The density classification developed by Harvey and Cowx (2003) might be used in assessing the status of sites fished. In the absence of specific funding this might again be achieved over time both in the continued lamprey studies and walkover surveys for enhanced maintenance as part of the Environmental River Enhancement Programme (EREP 2008 – 2012).

- *Development of GIS database:* This mitigation arises naturally from the previous section. Areas of potential lamprey habitat identified during walkover surveys and also areas which have previously been shown to contain lamprey should be mapped onto a GIS database. Using these data a GIS layer could be created which

would highlight key lamprey areas. This layer would be accessible to OPW technical staff programming maintenance operations and appropriate maintenance procedures could then be factored in well in advance for implementation.

It may be argued that juvenile lamprey often appear ubiquitous and that mapping locations of occurrence might impede all future maintenance operations. The mapping should indicate the importance, in terms of density, of individual sites and this would serve to highlight particular channels. The mapping of spot locations should be clearly distinguishable from the SNH habitat mapping within the GIS layer, as the latter provides continuity information and would be the primary guidance element in planning for works and mitigations.

7.2 Strategic Measures –short-term or immediate implementation

- *'No Go Areas':* The strategy of 'leaving sections alone' is one that is embraced in the environmental training protocol delivered to OPW's drivers. In that context, sections to be left alone were generally of a relatively high gradient and pertained to aspects of salmon and trout ecology, particularly to spawning. However, while salmonid spawning channel lengths tend to be of high grade and relatively self-cleaning, habitat for juvenile lamprey will tend to be of low gradient and conveyance issues may arise. During the course of this project, areas of lamprey abundance were identified. It is important that such areas are noted from previous studies and during walkover surveys and highlighted as potential 'no go areas' for maintenance on GIS maps. Juvenile lamprey are not highly mobile and are not capable of moving out of reach of the excavator bucket. All possible efforts to reduce impacts should therefore be put in place. Where significant areas of optimal habitat are observed and/or population densities have been recorded, these areas should be specifically addressed. There may be channel conveyance issues associated with 'leaving sections alone', particularly when these relate to low-gradient locations that may be facilitating instream weed growth and, hence, channel impedance. If it is not an option to leave such areas alone then particular other measures may be required. These might include retaining a significant portion of the habitat and/or collection and return of juveniles removed with spoil.

- *Maintenance frequency:* Both lamprey spawning habitat and juvenile nursery grounds have the potential to be impacted during maintenance. Maintenance cycles generally occur every 4-7 years and potentially more frequently on certain channels. If maintenance were to occur too frequently entire age classes could be lost from the population. This could lead to reduced numbers of lamprey returning to spawn, which, over time, could lead to the elimination of lamprey from the channel. A potential mitigation for this problem would be to leave longer time

periods between maintenance cycles in channels known to have substantial lamprey habitat and substantial lamprey populations. This may need to be balanced with overall river ecology considerations where long cycles may lead to more heavy-scale works.

- *Maintenance of channel segments:* OPW treats many of its larger channels as a series of segments, with maintenance operations moving sequentially upstream on an annual basis. This approach could also be extended to minor channels, of reasonable length, which contain known significant lamprey habitats or populations. Maintaining a reduced number of segments on a specific lamprey-bearing channel in any year would aid in the reduction of adverse impacts on lamprey populations. Studies involving fish species have found that undisturbed sections of channel provide refugia during maintenance as well as a seed population for recolonisation post maintenance (Kennedy 1980, Sedell *et al.* 1990). Recovery rates of fish populations following a disturbance are strongly influenced by the presence of undisturbed sections up and downstream of the disturbance (Niemi *et al.* 1990). These same principals are considered to apply to lamprey populations. Lamprey are mobile species and adjacent areas of channel could be utilised by the displaced population. Following maintenance, recolonisation of the impacted section of channel is then possible using the population of lamprey available in the adjacent sections. Evidence of such colonization comes from the studies in the OPW's Kilkenny Flood Relief Scheme (see 6.3.3 and 6.3.4 above).

- *Timing:* Presently OPW maintenance is restricted in salmonid spawning channels from October to May. However, this time frame does not encompass the entire breeding cycle of the three Irish lamprey species. It is also important to afford the same protection to channels which do not have breeding salmonid populations but have spawning lamprey populations. By extending the maintenance restriction to

the start of June in lamprey-bearing channels, a mitigation would be introduced that would essentially eliminate any adverse impact of maintenance on spawning of adult Brook and River lamprey. Lamprey do not spend the same length of time in gravelled substrate as salmonids and so timing restrictions in these channels could be reduced substantially while still covering the March – May period. This process would be facilitated by a GIS database of known lamprey spawning habitat, as discussed above. Additional data could be sought from the Regional Fisheries Board and the database built up over time as more information becomes available. Sea lamprey spawn during the summer months and, as such, the proposed maintenance restrictions to start June would not be adequate to protect spawning activity of this species. However, sea lamprey construct large redds at spawning sites, of similar dimensions to Atlantic salmon. Such structures would be evident in any channel and appropriate avoidance action could be undertaken under the supervision of the resident foreman, with advice from Fisheries Board personnel. Regional differences in spawning patterns for specific catchments and channels are possible. In such cases advice should be sought from Regional Fisheries Boards.

- *Directions of work:* Maintenance is generally carried out in an upstream direction It is noted that in some low grade channels maintenance is carried out in a downstream direction using the existing vegetation as a filter to reduce siltation.. It is the recommendation of this study that maintenance be carried out in an upstream direction on channels known to contain juvenile lamprey and/or juvenile lamprey habitat. If maintenance were to be carried out in a downstream direction, lamprey which have been displaced from upstream and have managed to find suitable downstream habitat will be impacted upon for a second time as the excavator tracks downstream. This would further reduce the chances of survival.

7.3 Operational Issues I - direct implementation of relevant elements from the OPW's 10-point environmentally-sensitive protocol

During the 5-year Environmental Drainage Maintenance (EDM) Programme (2002 – 2006), a training programme was agreed with OPW and rolled out to all staff of OPW's Drainage Maintenance division. This training was rolled out to OPW staff in the winter-spring period of 2002-03. Follow-up site visits were made to driver crews over the period 2003 – 2006.

The training provided an overview of river corridor ecology and biodiversity and also included a series of 10 practical elements that drivers could implement on-site. These were designed to reduced habitat damage and, in certain cases, provide a fisheries or wildlife benefit. The 10 practical elements were agreed to by OPW at a senior strategic and operational level and incorporated as part of normal practice for machine drivers in channel maintenance. Some of these elements have a particular relevance in lamprey mitigation terms and are reviewed below. Being in place already, these could be actively advanced as contributing to lamprey mitigation. It is of interest to note that several of these measures are identified in EcIA reports in this series as significantly lessening the potential impacts of maintenance activities on the freshwater pearl mussel (Anon 2008).

- *Non-working bank:* During maintenance there is an assumption made that the lamprey populations are equal on either side of the channel. This is also inherent in the SNH Walkover Survey protocol for lamprey habitat assessment. As part of the driver training programme, one of the recommended steps requires that the non-working bank should be left completely untouched. This would include the marginal vegetation. The measure was a general habitat one but has specific relevance for juvenile lamprey conservation. By ensuring that the non-working bank, along with its waters edge, marginal vegetation and the bank slope, are left

completely intact, it is assumed that 50% of the lamprey population are left completely undisturbed. Impacts to the water's edge on the working bank should also be kept to a minimum.

- *Confining excavation/maintenance to open-water area of channel:* This measure was one of the core points for implementation in the OPW's environmental protocol. It was devised to optimise conveyance while minimising ecological impact in the wetted channel. The velocity distribution and volume discharge tend towards a maximum in the mid-channel areas and maintenance can ensure that this pattern is continued by removing obstacles in the open channel area. Studies from the Kilkenny Flood Relief scheme (King and Lyons, unpublished data) demonstrated the absence of sediment from open water in this alluvial channel and its accumulation on channel margins. This is a normal pattern based on velocity distributions. As a consequence, juvenile lamprey are not, generally, found in the open water area of the channel but along channel margins in areas of siltation. By obtaining conveyance benefit in the open water area, adverse marginal impacts are avoided, to the benefit of resident lamprey populations. This measure will generally confine maintenance to two thirds of the channel with the remaining third consisting of the marginal vegetation and habitat at both banks.

- *Loosening channel-bed gravel:* Lamprey spawn on gravelled areas. Gravel shoals tend to collect on points of inflection or grade breaks of the channel bed. These areas are naturally self-cleansing of silt and deposition and do not, as a rule, require maintenance. As a matter of course, OPW will frequently skip over such areas in maintenance. This approach is further encouraged in the OPW driver training programme. Loosening or tossing has the effect of washing out fines from the gravel beds and, in the case of compacted or concretised gravel shoals, this can loosen the individual alluvial particles of appropriate spawning size and render the bed suitable for excavation by lamprey. The loosening is done by the machine crew using the teeth on the excavator bucket to rake over and agitate the bed. This is done as an alternative to leaving the section alone and constitutes a

value-added operation. However, this operation should only be done at a time of year when no intra-gravel life stages of salmon, trout or lamprey are present in the gravels. The recommended time period lies between 1st July and 30th September inclusive. Local variations on this time frame will occur, but only following advice or request from local Regional Fisheries Board staff.

- *Weed cutting bucket:* The maintenance requirement in many channels relates to heavy, often annual, growth of vegetation in the open-water. Such vegetation may consist of monocultures of water-celery type forms (*Apium* and *Rorippa*) or of tall emergents or 'flaggers' (principally *Sparganium erectum*). While these die back in autumn they can lead to elevated stage flow in summer conditions. In addition, celery can become dislodged through frost and high flows and float downstream in large rafts. These can block pipe culverts and accommodation bridges, leading to localized flooding issues. One of the training items for OPW proposed use of the machine bucket as a rake to collect up and then lift out, all water celery type vegetation from the channel. This would remove the conveyance constriction with minimal damage to the channel as no instream digging or desilting would be required. OPW now have weed cutting buckets that serve a similar purpose, in removing vegetation from the channel without impacting on sediment. The use of the weed cutting bucket is appropriate for the removal of water celery in early autumn. This measure would leave juvenile lamprey habitat unimpacted with obvious benefit to lamprey populations present.

- *Further Driver training:* The further development of driver training needs to be assessed. While on site visits, it became apparent that there was still much confusion among drivers when discriminating between lamprey and eels. Many drivers had developed a misimpression in regards to the size of juvenile lamprey, expressing surprise when shown samples of the animals taken from the spoil where they were excavating. Thus it is likely that lamprey occurrence has been under-reported by drivers simply through being unaware of the small size of these creatures. This can be addressed in the new Training Programme to be delivered

as part of the Environmental River Enhancement Programme (2008-2012). In the meantime OPW could put in place Standard Operating Procedures with coaching for machine operators.

7.4 Operational Issues II - Additional On-site mitigation measures

- *Bucket management - Increased drainage times and holes:* Allowing the water to drain from the excavation bucket, while suspended over the channel, for longer periods of time before the spoil is placed on the bank full/slope would permit a potentially greater degree of escapement by juvenile lamprey displaced into the bucket. The implementation of such a mitigation factor could be addressed as part of new driver training programmes. At present there are a number of holes in the excavator buckets. Increasing the number of holes in the buckets along with increasing the drainage times could increase the number of lamprey returning to the channels. A technique implemented for the protection of crayfish in the UK (Hogger and Lowery 1982) involves the operator 'dunking' the excavator bucket into the river in order to rinse the plant material, thus removing back to the channel any crayfish which have become entangled in plant material. A similar process could also be applied to lamprey. It is understood that a certain amount of sediment would return to the stream. However it is believed that the benefits to lamprey far outweigh this negative.

- *Checking spoil and reporting:* Increased checking of the spoils by driver crews is essential for the identification of new lamprey habitats and populations. Properly managed, it has the potential to deliver good data on presence and absence of lamprey on drained channels, with reporting from individual machine sites weekly over a period of five to seven years. This would add to our current data base detailing the national distribution of the species. If lamprey are identified as being regularly found in an area by drivers, a protocol should be put in place whereby that section of channel would receive an appropriate maintenance protocol - or no maintenance - depending on the density of lamprey present.

- *Returning lamprey to the channel:* It is important that lamprey found on spoil heaps are returned to the channels, especially in channels which have been designated as Special Areas of Conservation (SAC). This mitigation requires that one team member of the OPW machine crew picks over spoil excavated by his/her colleague, placing any lamprey into a bucket of fresh water. To be any way effective, the spoil must be spread thinly. This is a tedious process but has been shown to be effective in quantitative pilot-scale scientific studies. It is not clear how feasible such a process would be in extended whole-scale situations. It does represent a positive option in a situation where the works process is clearly having an adverse impact on the lamprey habitat and populations. However, it may require to be viewed in a context of maintenance logistics and cost:benefit appraisal of slowed machine time V extent of retrieval of lamprey and their replacement into an impacted habitat. This strategy would require that spoil be placed on the bankfull line or on spoil heaps and not on the bank slope, as it is not considered satisfactory for crew to carry out such picking on the bank slope itself. Working on the slope may have H&S implications and does not permit a proper spreading of spoil for examination and picking.

- *Deep waters:* Potential lamprey habitats are often not detectable during walkover surveys due to water depth. In cases like these the excavator bucket can be used as a sampling device in order to check for lamprey. If good numbers of lamprey are detected during maintenance then a strategy could be implemented whereby if >10 lamprey per m^2 are detected in sediment then the areas should be avoided. If <10 lamprey per m^2 are found then the area should receive appropriately sensitive maintenance. In all cases the marginal sediment should be left intact. An example of good maintenance which aimed to reduce the impacts of maintenance on lamprey was seen on the C1-Ownavorragh in September 2007. On this channel which was found to have >50 lamprey per scoop of sediment, maintenance was confined to the centre of the channel and marginal sediment and ‘flaggers’ were left intact.

- *Enhancements:* Traditionally OPW channels have been characterised by their trapezoidal cross sectional shape which does little to promote the deposition of silt in a manner conducive to juvenile lamprey. Frequently the channel is over-wide and, while this can permit sediment deposition, the deposits may be too thinly spread to create good lamprey habitat. If the cross sectional form were skewed with a deeper base on the outer side of the channel, this would promote deposition in the inner side, thereby increasing the amount of potential juvenile habitat. Even if these areas of sedimentation were colonised by 'flaggers' such as *Sparganium erectum* this would not be problematic as the current study has demonstrated that lamprey are capable of inhabiting areas at the roots of these plants.

- *Modification of OPW structures:* Where OPW structures, such as weirs and bridges, are blocking the upstream migrations of lamprey, modifications to these structures must be considered in the context of hymorphological continuity/fish passage requirements of the Water Framework Directive. Due to the extensive migrations undertaken by sea lamprey they are particularly vulnerable to becoming isolated through the introduction of weirs and other such impediments. It can be noted that the continuity problems may be more apparent on non-drained channels as the Arterial Drainage Schemes removed many large and small weirs as part of the work for flood conveyance.

  Bridges are an issue where flow continuity can be disrupted, with adverse impact on lamprey movement. Observations have identified channels where maintenance was undertaken in an upstream direction, as is common. However, in these cases, the maintenance has been undertaken to the extent that overdeepening of the channel bed took place. This resulted in lowering of bed level, and hence water surface level, up to the bridge but the 'regrading' could not be continued through the bridge floor, creating a step from low flow water level up onto the floor or

apron of the bridge. Such stepping can result in isolation of brook lamprey populations, in particular, both physically and, ultimately, genetically.

The elimination of barriers to hydromorphological continuity is integral to requirements of the Water Framework Directive. Lengths of overdug channels create problems for stability of bridge structures and aprons. Undertaking works to protect the infrastructure should also eliminate the physical ‘stepping’ effect and thus facilitate unimpeded lamprey adult passage to spawning areas. Such works may simply require placement of necessary amounts of rock armouring at the downstream end of the structure. This would serve the twin purposes of dispersing any downcutting by falling water as well as providing a continuum between the downstream water level and the bridge floor level.

8. Conclusion and Summary

It is apparent form Chapter 6 that OPW's maintenance programme has the capacity to have severe adverse impacts on populations of juvenile lamprey, resident in areas of sedimenting habitat. Their prevalence in areas of rooted vegetation in fine sediment, associated with stands of *Sparganium erectum*, is a further complication for OPW, in terms of addressing channel conveyance issues.

It is also clear that lamprey can recolonise relatively rapidly into new habitat. This would include post-maintenance habitat. Optimal population development would require adequate sediment deposition for colonisation.

A number of the mitigation measures proposed, particularly those strategic ones, will create a management climate where potential significant lamprey issues will be flagged well in advance in maintenance, enabling appropriate measures to be taken. Similarly, some of the strategic measures are already in place in OPW's general work processes but are not necessarily seen as pertinent to lamprey conservation and mitigation.

Operationally, there is, potentially, a real dilemma if OPW maintenance machines excavate moderate – substantial numbers of juvenile lamprey during maintenance. CFB has direct experience of sampling the contents of machine buckets in a quantitative manner. A decision to implement such an approach as standard when lamprey juveniles are encountered would have significant organisational ramifications for OPW, many of which are not the domain of this report. Given the fact that Waterways Ireland are operating such a protocol and given the fact that it does represent a realistic response to conservation of stranded juvenile lamprey, OPW should give consideration to the adoption of this strategy. The loss of habitat and the potential for survivors to find new living spaces are additional issues of concern, balanced against cost implications of slower progress in a channel maintenance operation.

Going forward, it is clear that OPW can anticipate encountering lamprey juveniles in a large number of its channels that require maintenance. In many cases, numbers will be small and populations patchily distributed. In many other cases, however, it is very likely that substantial population densities will be encountered in areas of optimal habitat. It is inevitable that loss of habitat will occur and that mortalities will occur. The only way to prevent this is to implement those channel conveyance improvement measures that do not impact on the channel bed in areas of deposition. This would, in turn, preclude management of sediment deposition and of marginal and instream vegetation associated with such soft sediments.

The above will be the case, be the channel in a SAC or not. The occurrence of juvenile lamprey habitat and populations presents a real conservation dilemma to OPW in expediting its legal obligations to channel maintenance under the1945 Arterial Drainage Act. The dovetailing of such obligations with conservation requirements of lamprey and development of agreed outcomes will, it is hoped, be advanced through use of this EcIA document and its proposals. In particular, close liaison between OPW, National Parks and Wildlife Service and the Fisheries Boards service is required to develop consistent and agreed processes in regard to channel maintenance in lamprey habitats.

9. References

Anon 2008 Ecological Impact Assessment (EcIA) of the effects of statutory arterial drainage maintenance activities on freshwater pearl mussels (Margaretifera margaretifera and M.m durrovensis). *Series of Ecological Assessments on Arterial Drainage Maintenance* No. 7. Office of Public Works, Dublin.

APEM 2004. Assessment of sea lamprey distribution and abundance in the River Spey: Phase II. *Scottish Natural Heritage Commissioned Report No. 027 (ROAME No. F01AC608).*

Applegate, V. C. 1950 Natural history of the sea lamprey, *Petromyzon marinus* in Michigan. Special Scientific Report U. S. Fish Wildlife Service No. 55: 1-237.

Brookes, A. 1987 The distribution and management of channelized streams in Denmark. *Regulated Rivers* 1, 3-16.

Byrne, C., Igoe, F., Cooke, D., O'Grady, M. F. and Gargan, P. 1998 The distribution of the brook lamprey *(Lampetra planeri*, Bloch) in the Lough Corrib catchment in the west of Ireland and some aspects of its biology and ecology. *Verein Internationale Verein Limnologie.* 27: 2066-2070.

Connor, L.L. 2006 The distribution and ecology of lamprey in the River Nore catchment. M.Sc. Thesis, Trinity College, University of Dublin.

EIRE 1945 Arterial Drainage Act 1945, No. 3 of 1945. Stationery Office, Dublin.

Gardiner, M.J. and Radford, T. 1980 *Soil associations of Ireland and their land use potential*. An Foras Taluntais, Dublin 142pp.

Gilligan, N. and Dooley, R. 2007 Screening of Natura 2000 sites for impacts of arterial drainage maintenance operations. *Series of Ecological Assessments on Arterial Drainage* Maintenance No. 1. Office of Public Works, Dublin.

Hardisty, M. W. and Potter, I. C. 1971 The general biology of adult lampreys. In M. W. Hardisty and I. C. Potter (eds.) *The Biology of Lampreys*, Volume 1, Academic Press, London.

Harvey J & Cowx I. 2003. Monitoring the River, Brook and Sea Lamprey, *Lampetra fluviatilis, L. planeri and Petromyzon marinus*. Conserving Natura 2000 Rivers Monitoring Series No. 5, English Nature, Peterborough.

Hockin, D.L. 1985 The impact of river channelization II Channelization : Some engineering aspects. *The Geographical Journal* 151, 54-57.

Hogger, J.B. & Lowery, R.S. 1982. The encouragement of freshwater crayfish populations by attention to the construction and maintenance of waterways. *Journal of Institution of Water Engineers and Scientists*, 36, p214-220.

Howard, J. 1980 Current practise in assessing drainage impacts. IN : *Impacts of Drainage in Ireland*. NBST workshop, Dublin. Paper 7, 1-39.

IEEM 2006 *Guidelines for Ecological Impact Assessment in the United Kingdom*. Institute of Environmental Ecology and Management http://www.ieem.net/ecia/index.html 17.9.2008

Igoe, F., Quigley D.T.G., Marnell, F., Meskell, E., O'Connor W. and Byrne, C. 2004. The sea lamprey *Petromyzon marinus* (L.), river lamprey *Lampetra fluviatilis* (L.) and brook lamprey *Lampetra planeri* (Bloch) in Ireland: General biology, ecology, distribution and status with recommendations for conservation. *Biology and Environment: Proceedings of the Royal Irish Academy.* 104b (3): 43-56.

Kelly, F. L. and King, J. J. 2001 A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): a context for conservation and biodiversity considerations in Ireland. *Biology and Environment : Proc. R. Ir. Acad. 101B*, 165-185.

Kennedy, G.J.A. 1980 Drainage related changes in salmonid and invertebrate populations in the River Camowen. *Proceedings of the Institute of Fisheries Management Conference*, Magee University College, 63-80.

King, J.J. 1996. Channel maintenance in drained Irish catchments : experimental strategies, ecological impacts and management implications. Ph.D. Thesis, National University of Ireland, 160pp.

King, J.J. 2006. The status and distribution of lamprey in the River Barrow SAC. *Irish Wildlife Manuals* No. 21. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

King, J.J, O'Grady, M.F. and Curtin, J. 2000. The Experimental Drainage Maintenance (EDM) Programme: engineering and fisheries management interactions in drained Irish salmonid channels. *Verein Internationale Verein Limnologie.* 27: 1532-1535.

Lynn, M.A. 1980 The arterial drainage programme : its background, economic and environmental effects. IN : *Impacts of drainage in Ireland*. NBST Workshop, Dublin. Paper 1, 1-12.

Maitland, P. S. 2003. Ecology of the River, Brook and Sea Lamprey. *Conserving Natura 2000, Rivers Ecology Series No. 5*. English Nature, Peterborough.

Maitland, P.S. and Campbell, R .N. 1992 *Freshwater Fishes*. Harper and Collins, London.

Moser, M.L., Butzerin J.M. and Dey, D.B. 2007. Capture and collection of lampreys: the state of the science. *Reviews in Fish Biology and Fisheries*. 17: 45-56

Niemi G. J., DeVore P., Detenbeck N., Taylor D., Lima A., Pastor J. 1990 Overview of case studies on recovery of aquatic systems from disturbance. *Environmental Management* 14, 571-587.

O'Connor, W. 2004. A survey of juvenile lamprey populations in the Moy catchment. *Irish Wildlife Manuals* No. 15. National Parks and Wildlife Service. Dept. of Environment, heritage and local Government, Dublin Ireland.

O'Connor, W. 2006a. A baseline survey of juvenile lamprey populations in the River Feale catchment. *Irish Wildlife Manuals* No. 22. National Parks and Wildlife Service. Dept. of Environment, heritage and local Government, Dublin Ireland.

O'Connor, W. 2006b. A survey of juvenile lamprey populations in the Boyne catchment. *Irish Wildlife Manuals* No. 24. National Parks and Wildlife Service. Dept. of Environment, heritage and local Government, Dublin Ireland.

O'Connor, W. 2007. A survey of juvenile lamprey populations in the Corrib and Suir catchments. *Irish Wildlife Manuals* No. 26. National Parks and Wildlife Service. Dept. of Environment, heritage and local Government, Dublin Ireland.

O'Flynn, T.P. 1932 Notes on the design of arterial drainage schemes. *Transactions of the Institution of Civil Engineers of Ireland*, 58, 233-274.

Ryan, T.D. 1986 Agricultural drainage practises in Ireland. *Environmental Geology and Water Sciences* 9, 31-40.

Schoof, R. 1980 Environmental impact of channel modification. *Water Resources Bulletin* 16, 697-701.

Sedell J. R., Reeves G. H., Hauer F. R., Stanford J. A., Hawkins C. P. 1990 Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. *Environmental Management* 14, 711-724.

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