2010

Lamprey Baseline Surveys: River Finn and River Deele Co Donegal

Loughs Agency of the Foyle Carlingford and Irish Lights Commission

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Lamprey Baseline Surveys: River Finn and River Deele, Co Donegal, 2010

2011

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Executive Summary

Baseline surveys were conducted to record the abundance and distribution of juvenile lamprey within the River Finn and River Deele catchments during the summer and autumn of 2010. Both catchments are located in the Loughs Agency jurisdiction lying within County Donegal, Republic of Ireland.

The surveys utilised a methodology followed by Inland Fisheries Ireland (IFI) and outlined in the Conserving Natura 2000 Rivers Monitoring Series No. 5. Monitoring the River, Brook and Sea Lamprey. Training was provided by IFI prior to the commencement of the catchment wide surveys.

Three lamprey species occur in the Foyle area, sea lamprey, *Petromyzon marinus* (L.), river lamprey *Lampetra fluviatilis* (L.), and brook lamprey, *Lampetra planeri* (Bloch). Unidentified juvenile lampreys have been recorded in the Carlingford area.

Monitoring and reporting of lamprey conservation status in the context of the EU Habitats Directive (Directive 92/43/EEC) is discussed and future survey proposals outlined for both Special Areas of Conservation (SAC) and non SAC catchments within the Foyle and Carlingford areas.

The report highlights the importance of monitoring, conserving and protecting lamprey populations in the context of wider biodiversity conservation and education to ensure sustainable management of these unique parts of Irelands native fishery biodiversity.

Previous records of lamprey presence within the Foyle and Carlingford areas are displayed and past and future recording systems discussed.

In parallel to King (2006) sampling in the main stem of the River Finn was hampered by excessive depth for the sampling technique used.

Threats to the long term conservation of lamprey populations are highlighted and discussed with particular reference to the Foyle and Carlingford areas.

Recommendations for further research into the lamprey populations of the Foyle and Carlingford areas are made.

1.0 Introduction

Lampreys are members of a primitive group of fish called the Agnatha or jawless fish. The first Agnathans can be dated back to the Ordovician period about 500 million years ago. Lampreys in addition to having no jaws lack scales or paired fins (Kurz and Costello, 1999). Adult river and sea lampreys have a toothed oral disc which they use to attach to prey where they parasitically feed on the hosts body fluids. Brook lampreys remain in freshwater for their entire life and are non parasitic. Lampreys have seven gill openings on each side of their body with distinct eyes forming prior to adulthood. As mature adults the three species native to Ireland can easily be distinguished by their size, colour, shape of dorsal fins and the arrangement of their teeth (Kurz and Costello, 1999).

Sea and river lampreys are anadromous migrating between the freshwater and marine environments, returning to freshwater to breed in gravel shallows. Man made barriers to migration in rivers such as weirs and dams have reduced the available area of aquatic habitat accessible to both these species. Spawning nests called redds are built by all lamprey species. The larger sea lamprey prefer cobbles and pebbles for spawning, where they spawn in pairs or small groups, river lamprey prefer sandy or gravelly sediment where they also spawn in pairs. Brook lamprey spawn in smaller slower flowing tributaries preferring spawning substrate similar to that used by the river lamprey where they spawn in groups of ten and over. All adult lampreys die after spawning.

The three species of lamprey present in Ireland have complex life histories which vary depending on the species and location. All three species also have many common biological and ecological traits. Similarities include a common juvenile stage where after hatching from the redd the larvae called ammocoetes create burrows in river detritus and fine sediments in back eddies or other areas of slack water. After spending a number of years (dependant on species) feeding on organic material metamorphosis occurs with the amoecetes transforming into macropthalmia often referred to as transformers where a visible eye is now present. It is at this stage when the river and sea lamprey migrate to sea to begin their parasitic phase feeding on a variety of fish hosts.

Ammocoetes of all three species look very similar and can be found in the same areas although brook lamprey juveniles tend to be more dispersed throughout catchments as they do not have to ascend obstacles on a return migration from the sea. Differentiation between species at this juvenile/ammocoete stage is difficult with field based identification often being limited to identifying only between river/brook and sea lamprey.

The diagram below outlines the life cycle of anadromous lampreys (River and Sea lamprey).

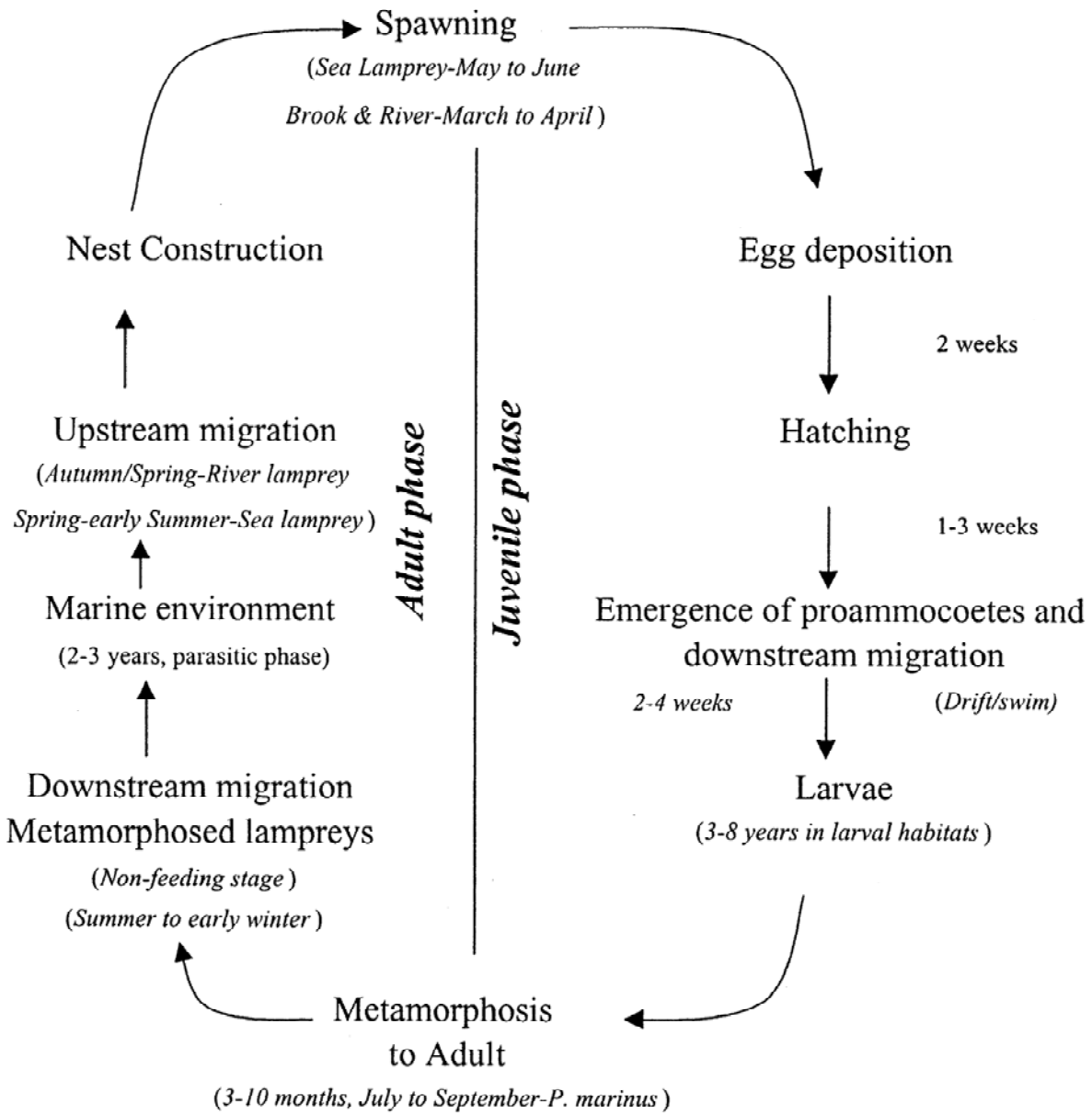

Fig 1. Life cycle of anadromous lampreys (Kelly & King 2001)

All three lamprey species are known to occur in the Foyle area while unidentified species of lamprey are present in the Carlingford area.

All three lamprey species are also designated under Annex II of the European Union Habitats Directive (Directive 92/43/EEC) requiring member states to designate Special Areas of Conservation (SACs) for their protection. In the Foyle area there are five large river SACs designated under the Habitats Directive. The River Foyle and Tributaries, the River Roe and Tributaries, the River Faughan and Tributaries, the Owenkillew River and the River Finn and Tributaries. All listed SACs apart from the last two have all three lamprey species listed as site selection features amongst other species and habitats. The Owenkillew only has brook lamprey listed as a site selection feature and the River Finn and tributaries does not have any lamprey species as site selection features. Under the Habitats Directive site condition monitoring against favourable conditions for lamprey species should be made on a six yearly rolling basis. The next date for reporting on condition monitoring is 2013.

The reason for designating and managing SACs is to maintain at, or restore to, “favourable conservation status” the habitats and species listed on annexes I and II of the directive (Harvey & Cowx, 2003).

Existing records did not provide enough information on the species specific abundance and distribution required for site condition monitoring. A need was identified to implement a specific methodology for assessing condition as required under the Habitats Directive within the Foyle and Carlingford areas. The methodologies adopted during this survey followed those developed by IFI incorporating recommendations made in the LIFE in UK Rivers, Conserving Natura 2000 Rivers, Monitoring Series No 5. Monitoring the River, Brook and Sea Lamprey (Harvey & Cowx, 2003).

2.0 Methods

The surveys took place from August to October 2010 and focused on recording the abundance and distribution of juvenile lamprey. Sampling was conducted using electrofishing techniques following standard

procedures to ensure future comparison of data between rivers and years. This will facilitate identification of any trends between years and highlight increasing or declining population trends.

Fig 2. Lamprey ammocoete sampling equipment minus electrofishing equipment

Site selection was based on the location of existing Environmental Protection Authority (EPA) water quality monitoring stations. Once at the chosen site appropriate areas of sediment (optimal habitat) in low velocity areas and in wadable depth were located where possible.

Fig 3 Example of optimal lamprey ammocoete habitat

An area of approximately 200m upstream and 200m downstream from all sites were examined for appropriate optimal habitat. If no optimal habitat was located sub optimal habitat was surveyed.

The methodologies employed for surveying lamprey ammocoetes varies from those used for juvenile salmonids and requires a dedicated survey. Three sampling techniques were used during the lamprey survey.

The first technique was a quantitative method using electrofishing within a fine mesh quadrat framework with a base area of 1m². This was used to conduct removal sampling with lamprey being removed by hand net . See Fig 4.

Fig 4. Quantitative survey methodology within 1m² quadrat

Using pulsed DC a single anode was used within the quadrat avoiding contact with the substrate. Over a two minute period the anode was energised for 20 seconds and turned off for five seconds repeatedly. All fish captured during the first 2 minute period were placed in a separate bucket from future sampling periods. A 5 minute break was taken between 2 minute sampling periods. If captures during the second period represented a high fraction of the size of the first catch then it was deemed appropriate to do a third fishing. Approximately 50% depletion between sampling periods is required to facilitate density estimates.

All electrofishing was conducted using an Electracatch International ELBP2 backpack. Immobilised ammocoetes were removed using a fine mesh catching net and transferred to a bucket of water. All ammocoetes and transformers were identified as river/brook lamprey or sea lamprey and measured.

Electrofishing in sub optimal habitat was conducted using a semi quantitative methodology over a defined area of riverbed. The area

sampled was measured accurately so that a minimum density estimate could be derived. The sampling methodology was similar to the quantitative method with the area fished multiplied by two to give the fishing time in minutes. The total fishing time was then divided into 20 second bursts followed by 5 second breaks. No enclosure was used and all lampreys were collected and measured.

Fig 5. Semi quantitative sampling methodology

Minimum density estimates based on area fished and density estimates based on removal sampling results were calculated for each site at which lampreys were present and are outlined in the results section.

Push net sampling was also conducted as an exploratory tool to ascertain if it was worthwhile conducting electrofishing operations at sites with sub optimal habitat. The contents of a micro mesh kick net were emptied onto a small tarpaulin for close examination for lamprey ammocoetes. If ammocoetes were present either a quantitative survey or a semi quantitative survey were conducted depending on the area of available habitat.

Fig 6. Young of the year River/Brook lamprey ammocoete

Fig 7. Lamprey ammocoetes and associated sediment/detritus

Fig 8. River/Brook lamprey ammocoete

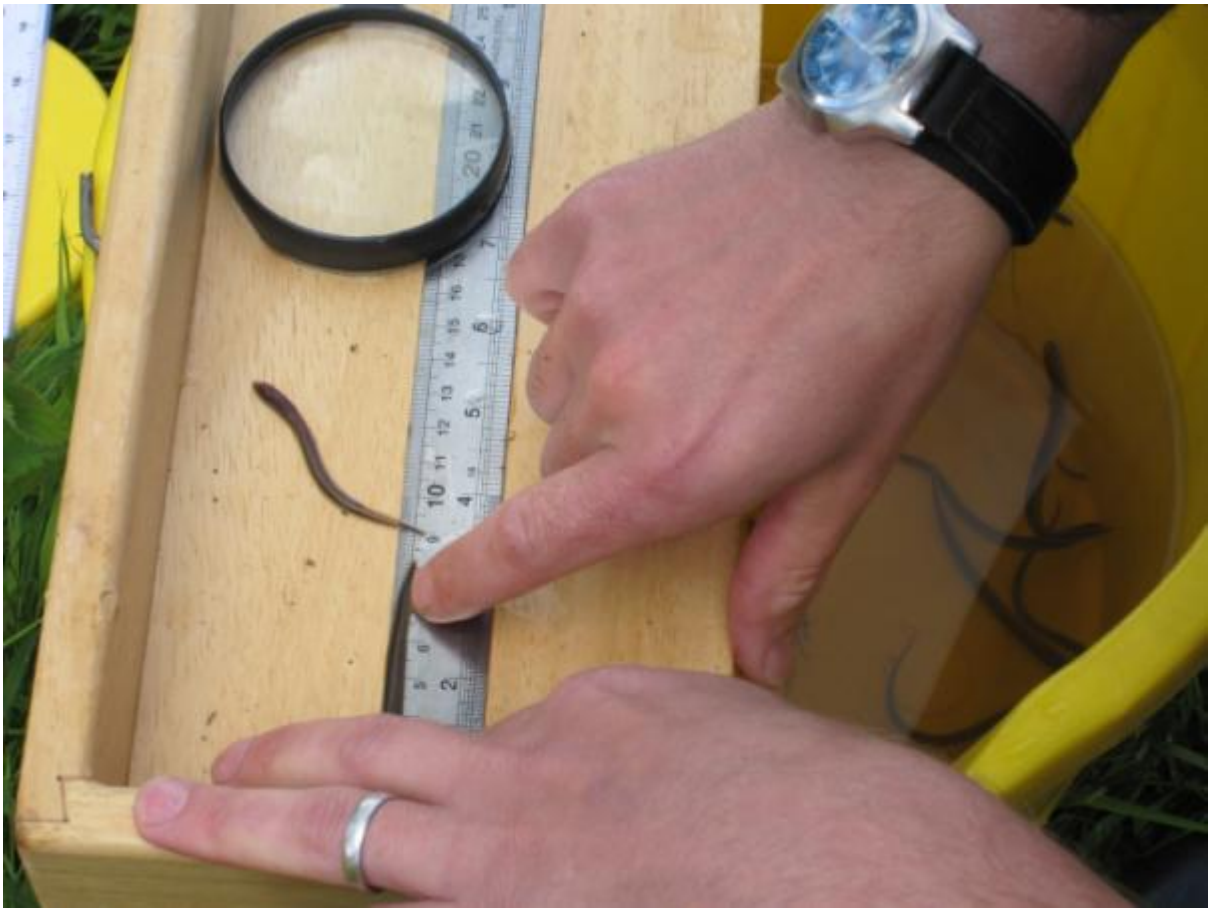

Fig 9. Measuring River/Brook lamprey ammocoete length

Figures 6-9 show River/Brook lamprey caught during the current study highlighting the diversity of sizes encountered from small young of the year to larger age classes possibly up to 5 years in age. At the ammocoete stage it is not possible to identify the difference between a River and a Brook lamprey. For identification purposes lamprey ammocoetes were recorded as either River/Brook or Sea. River/Brook lamprey ammocoetes have an oral hood that is clear of pigmentation on the lower side and the caudal fin is spade shaped with pigmentation not extending into the caudal fin, see Fig 10. Sea lamprey ammocoetes have pigmentation throughout the oral hood and have a pointed caudal fin with black pigmentation present through the caudal fin Fig 11. Fig 12 also shows the differences between River/Brook and Sea lamprey ammocoetes.

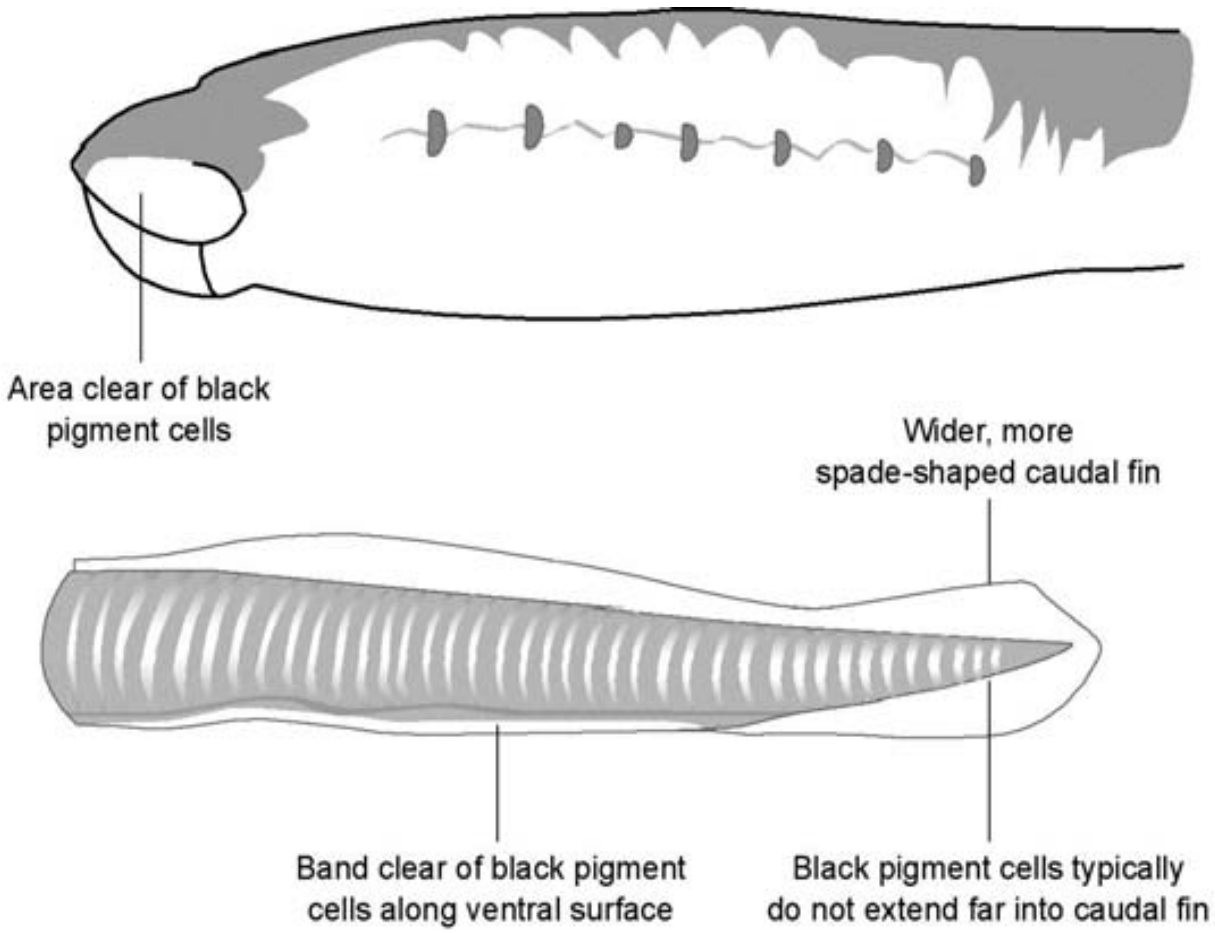

Fig 10. River/Brook lamprey ammocoete, features to aid identification, courtesy of Conserving NATURA 2000 Rivers

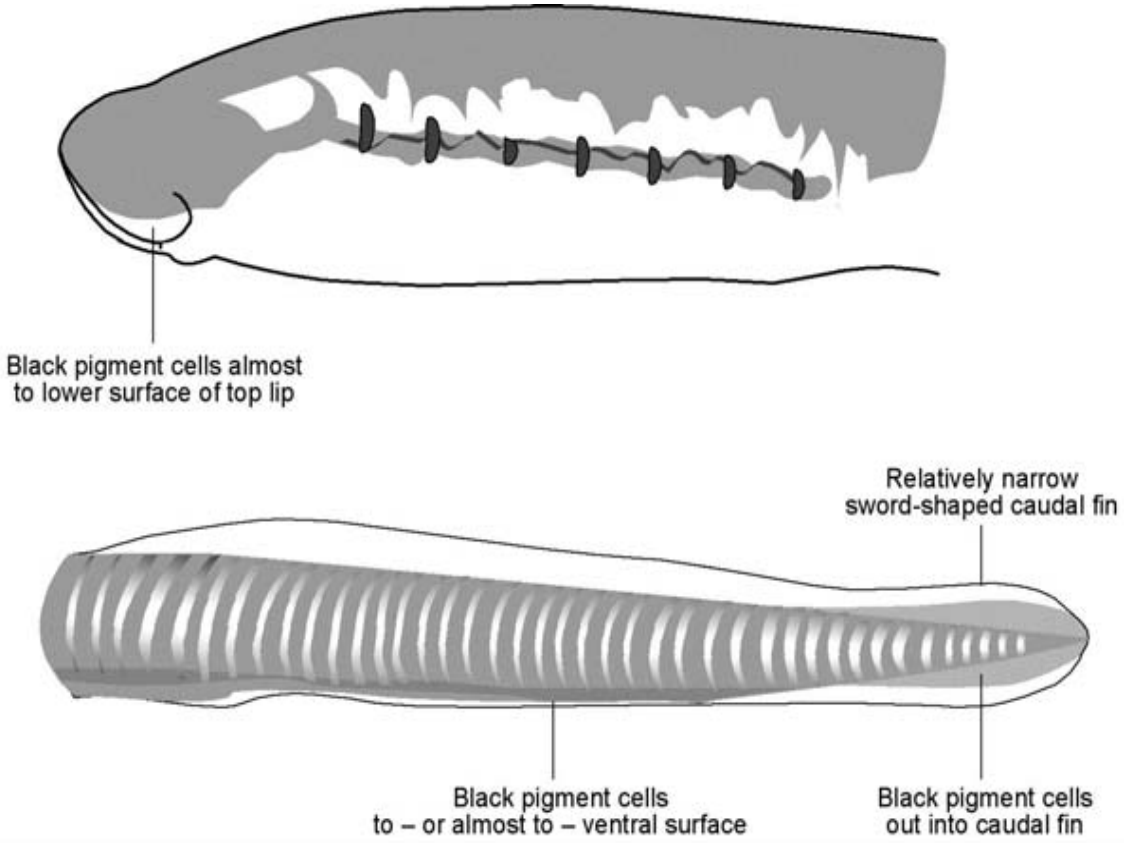

Fig 11. Sea lamprey ammocoete, features to aid identification, courtesy of Conserving NATURA 2000 Rivers

Fig 12. Top sea lamprey ammocoete and bottom River/Brook lamprey ammocoete. *Note differences in tail shape and pigmentation.

Sediment core samples were taken at all sites were lamprey were present and as part of a habitat utilisation study will be sieved to see the sediment type preferred by lamprey ammocoetes. All other relevant information was recorded on an appropriate survey data record form.

As lamprey ammocoetes can transform into adults during the period the survey was conducted any transformers were also noted Figs 13 & 14.

Fig 13. River/Brook lamprey transformer from the River Finn

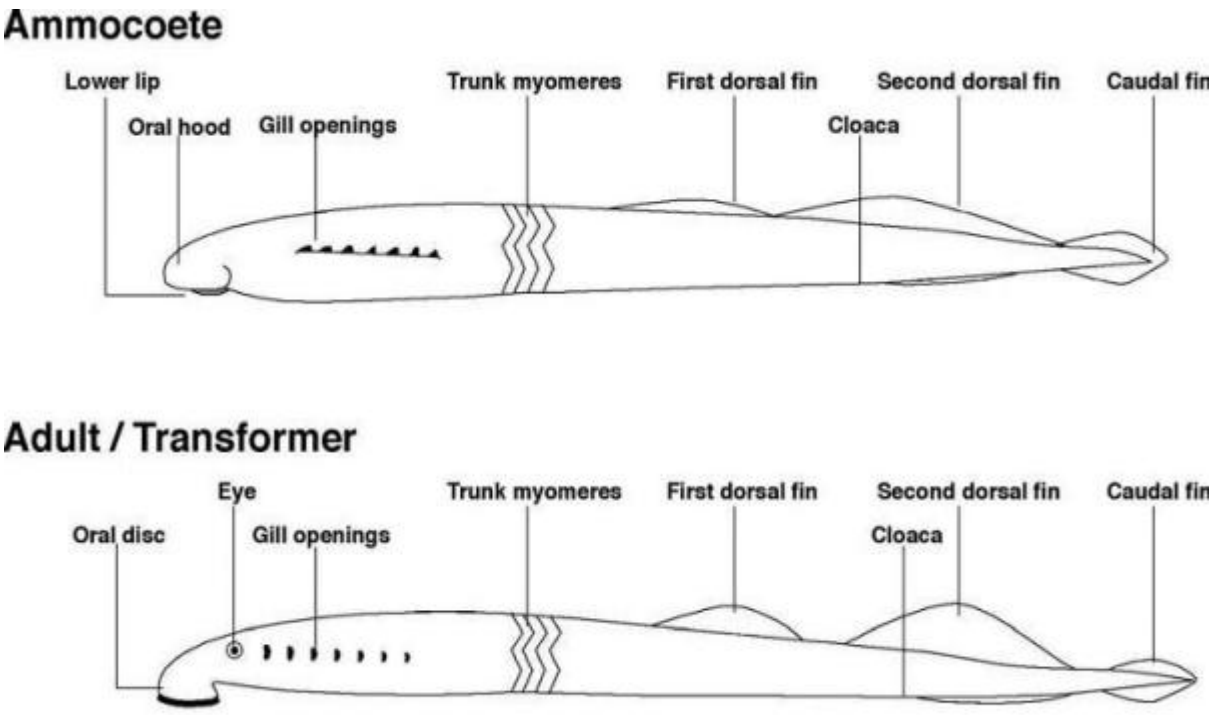

Fig 14. Lamprey ammocoete and adult/transformer, features to aid identification, courtesy of Conserving NATURA 2000 Rivers

All existing and historical records available for lamprey distribution within the Loughs Agency jurisdiction were collated as part of the current study forming a baseline of known lamprey distribution. These records were entered into the Loughs Agency Geographical Information System (GIS) for future reference and will be updated with results from future targeted lamprey surveys. These records are divided into five categories; Lamprey spp (unknown species), Brook lamprey, River/Brook lamprey, River Lamprey and Sea Lamprey. This data has been collated from a variety of sources reporting on other fisheries surveys where lamprey were caught or observed. This is in addition to the results generated from the current study.

Fig 15. Adult sea lamprey caught in a Rotary Screw Trap (RST) on the River Finn, Co Donegal 2006

3.0 Results

Prior to this survey Loughs Agency records of lamprey distribution within the Foyle and Carlingford areas were stored in a variety of locations and were largely undifferentiated for species. As part of the current study all known records for the distribution and abundance of the three lamprey species by life history stage (if known) within the Foyle and Carlingford areas were collated into a spatial database within the Loughs Agency Geographical Information System (GIS). This information is presented below in Figure16 & 17.

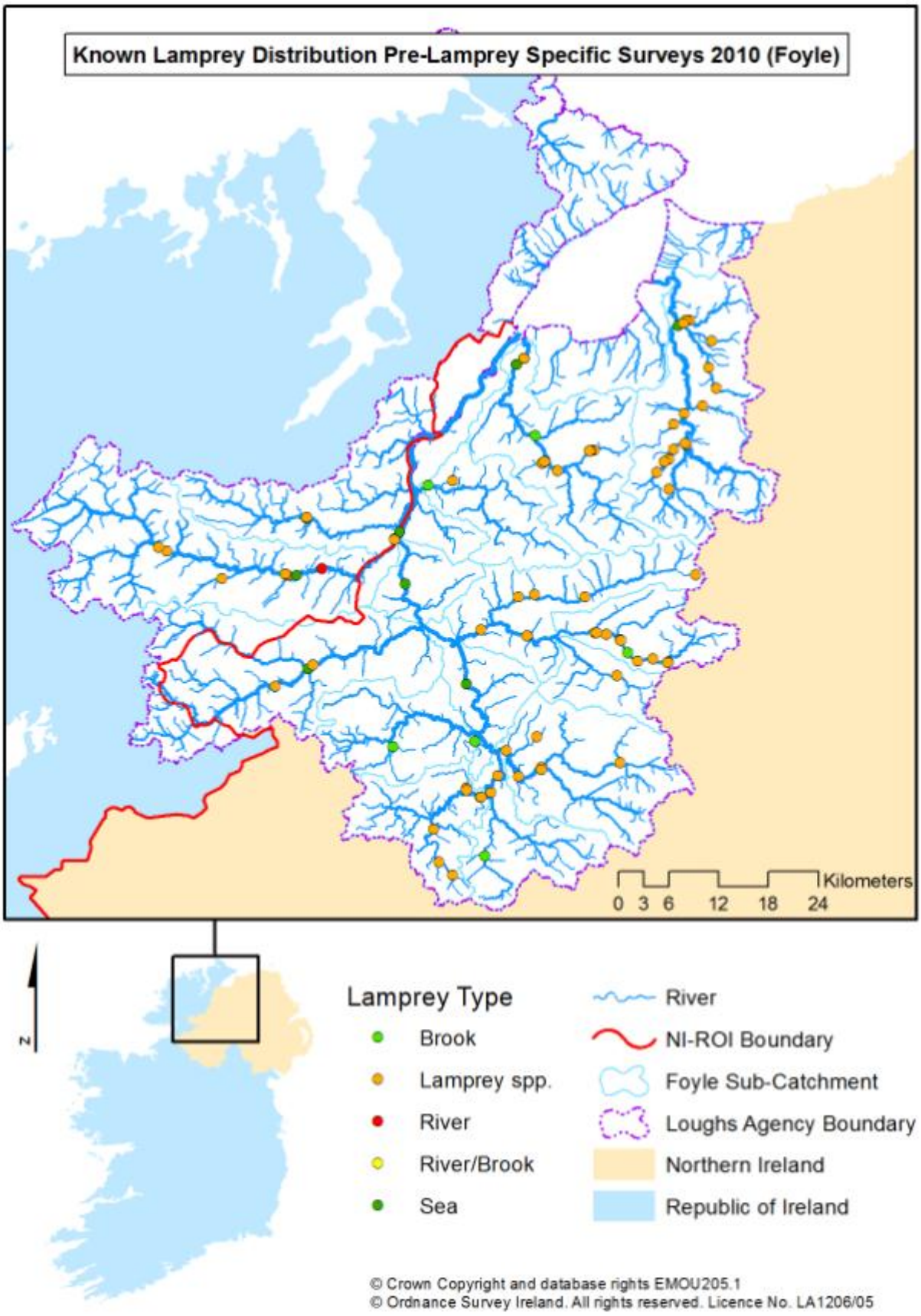

Figure 16. Known lamprey distribution within the Foyle area prior to current study.

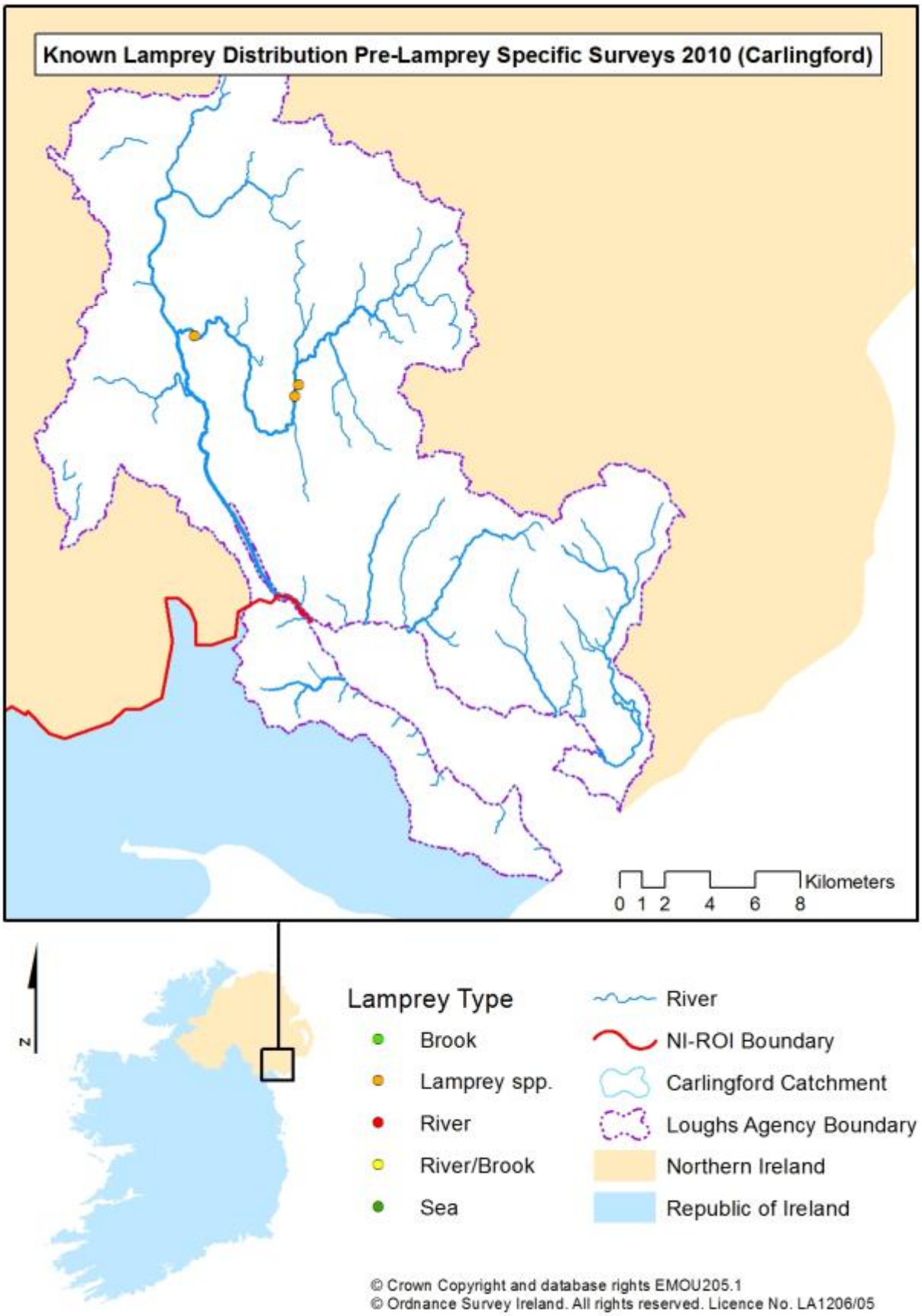

Figure 17. Known lamprey distribution within the Carlingford area.

In 2010 twelve sites were surveyed within the Deele catchment with lamprey ammocoetes recorded at four sites in optimal habitat only. Minimum density of *Lampetra* ammocoetes ranged from 0 /m² to 24/m² with a mean minimum density of 5.6/m². *Lampetra* ammocoete populations at three of the four sites (sites 8, 10 and 11) on the Deele showed signs of recruitment (0+ individuals). Older ammocoete cohorts were present at all four sites. No transformers were caught within the Deele catchment. In summary *Lampetra* ammocoetes were present at 33% of sites surveyed in the Deele catchment with various age classes present at these sites.

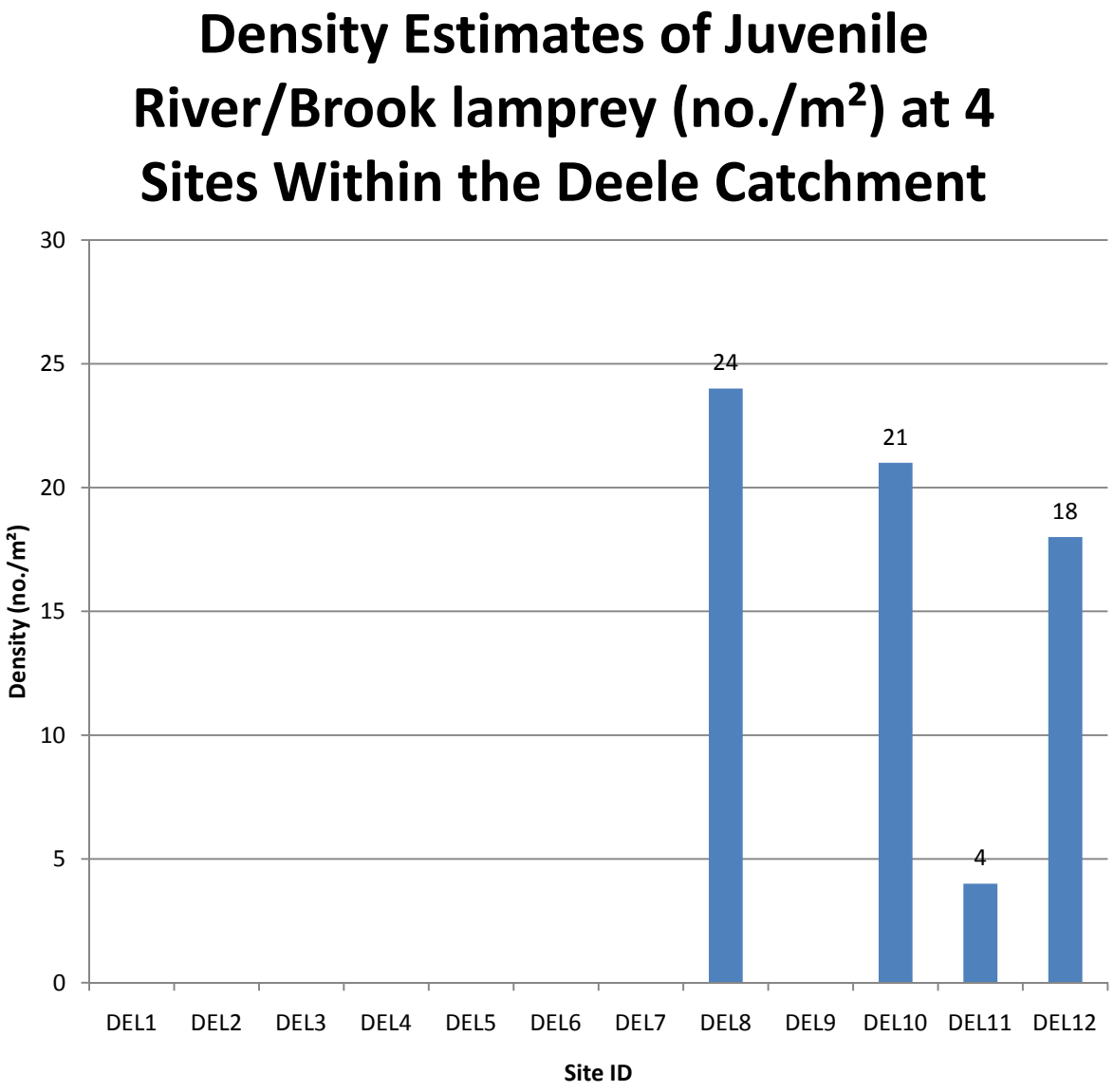

Figure 18. Juvenile River/Brook lamprey density estimates from the 12 sites surveyed within the Deele catchment, 2010.

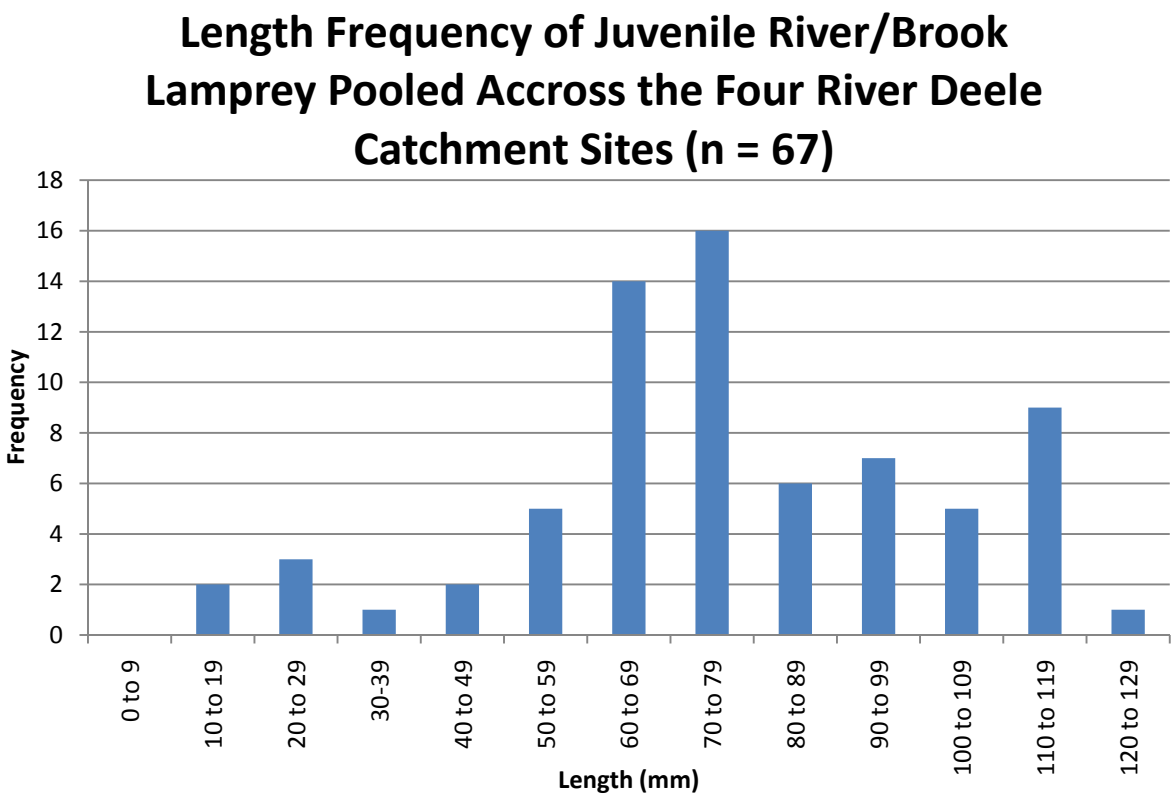

Fig 19. Length frequency distribution of all juvenile River/Brook lamprey caught within the River Deele, 2010.

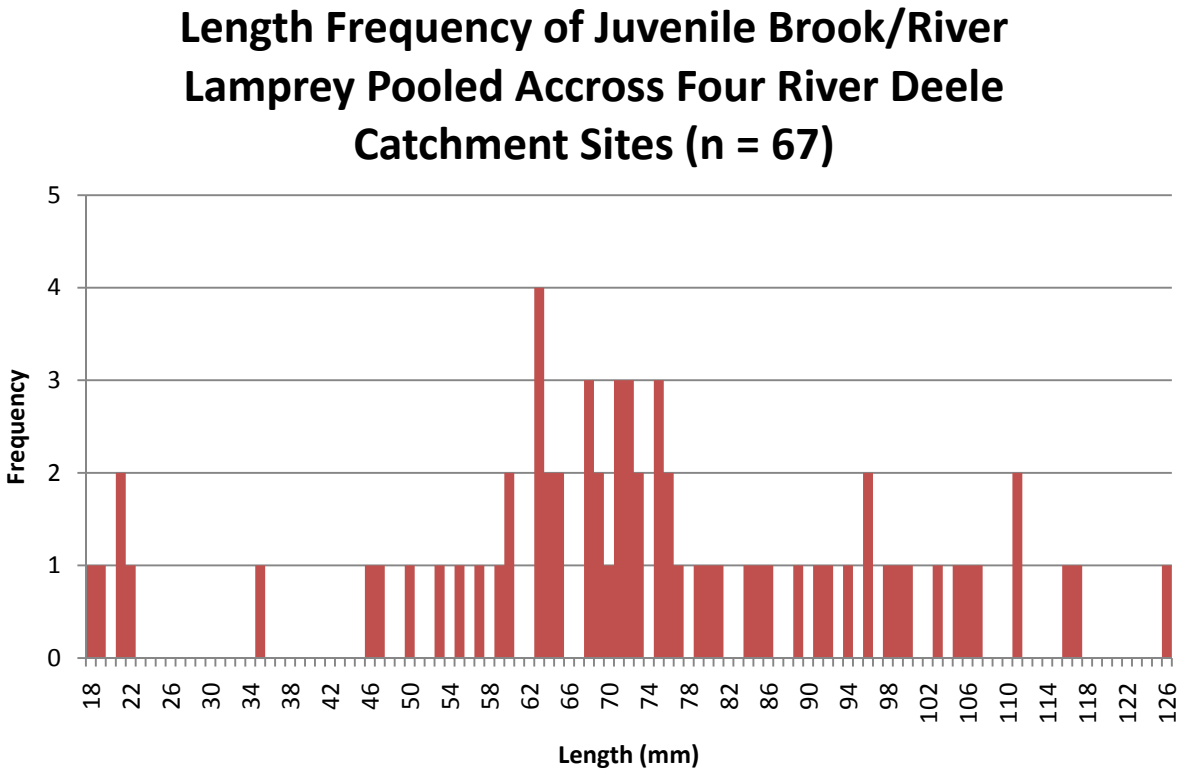

Fig 20. Length frequency distribution of River/Brook lamprey caught at all sites within the Deele catchment during the 2010 survey.

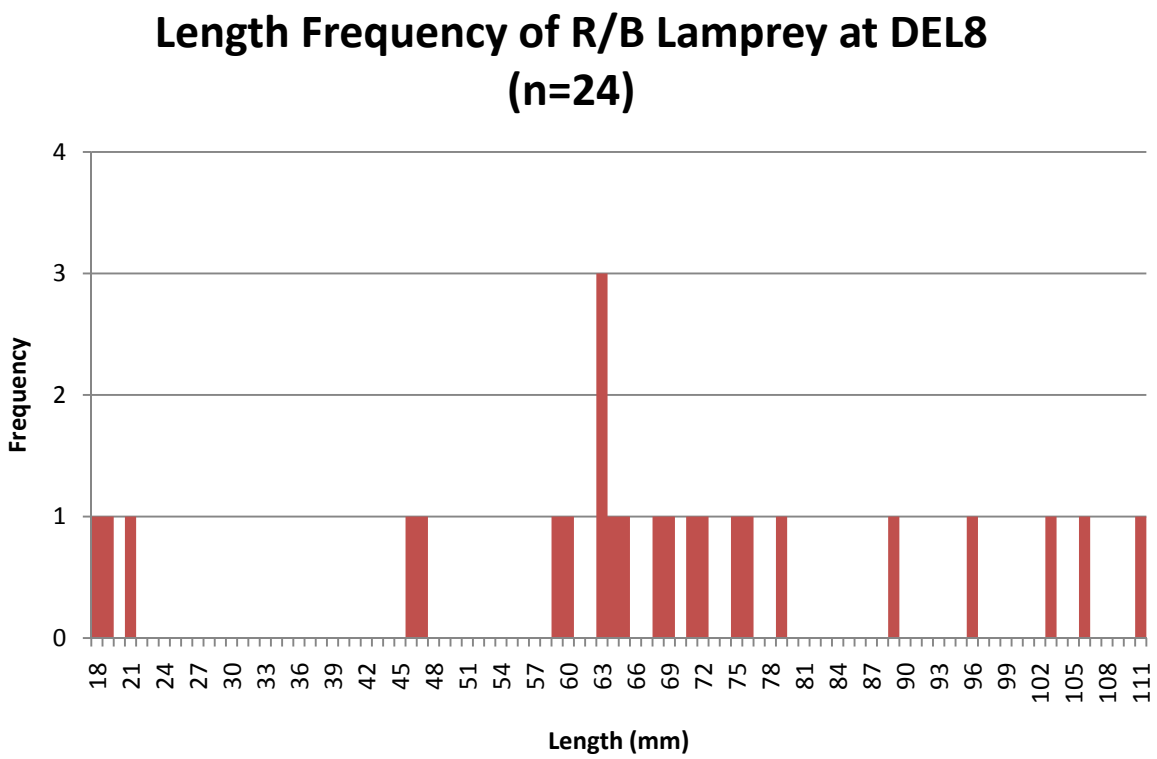

Fig 21. Length frequency distribution of River/Brook lamprey caught at site DEL8, 2010

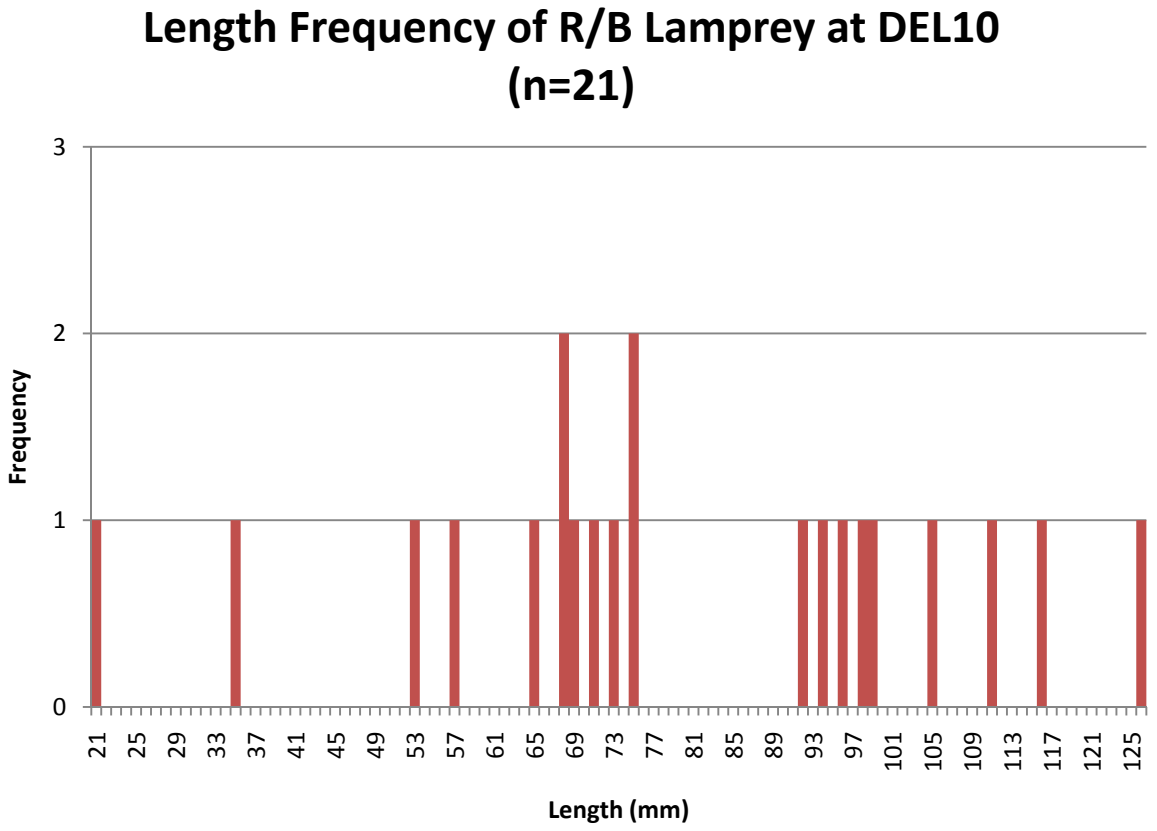

Fig 22. Length frequency distribution of River/Brook lamprey caught at site DEL10, 2010.

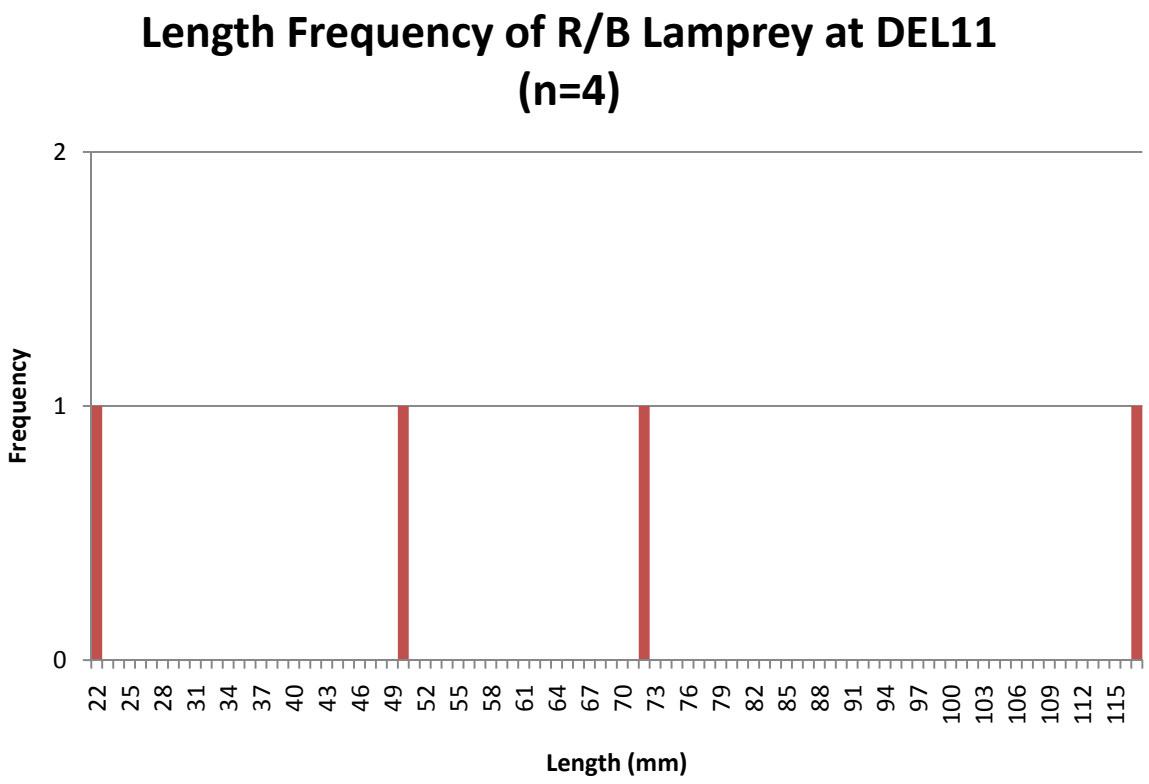

Fig 23. Length frequency distribution of River/Brook lamprey caught at site DEL11, 2010.

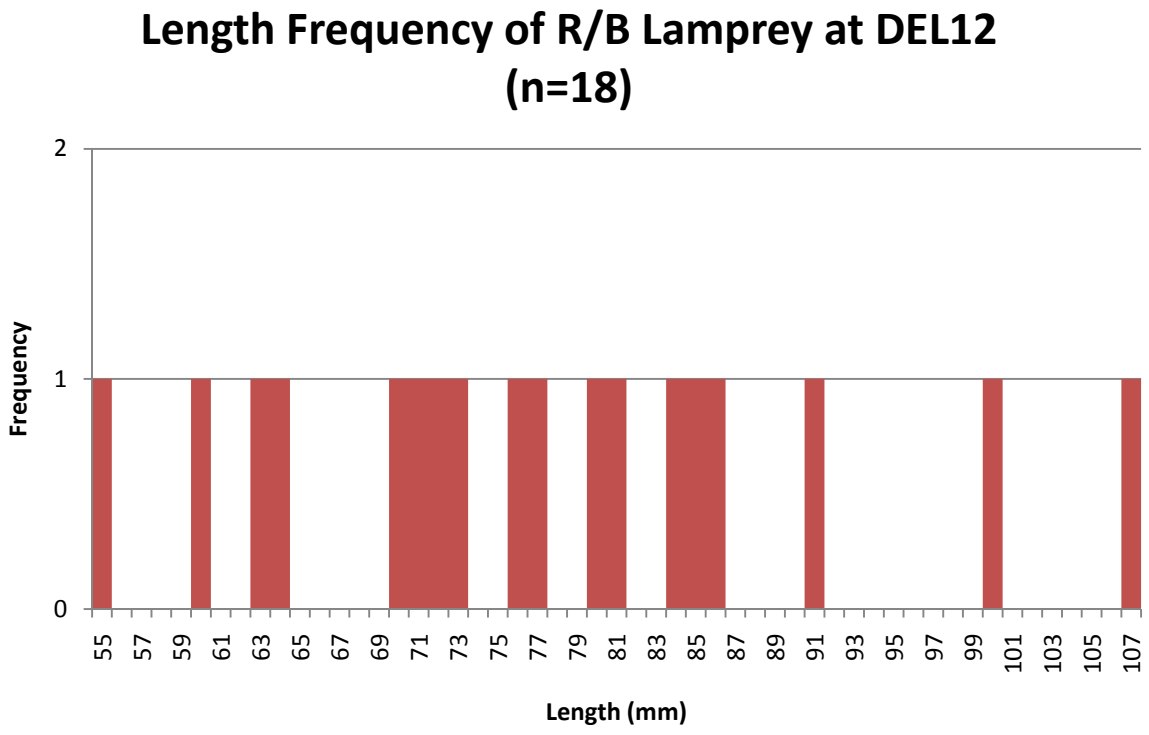

Fig 24. Length frequency distribution of River/Brook lamprey caught at site DEL12, 2010.

Twenty four sites were surveyed within the Finn catchment with lamprey ammocoetes recorded at one site in optimal habitat. Out of the twenty four sites surveyed only three were classified as optimal habitat. Minimum density of *Lampetra* ammocoetes ranged from 0 /m² to 72 /m² with a mean minimum density of 3 /m². *Lampetra* ammocoete populations at the only positive site on the Finn showed signs of recruitment (0+ individuals), older ammocoete cohorts were also present at this site. Transformers were caught within the Finn catchment. In summary *Lampetra* ammocoetes were present at 4% of sites surveyed in the Finn catchment with various age classes present.

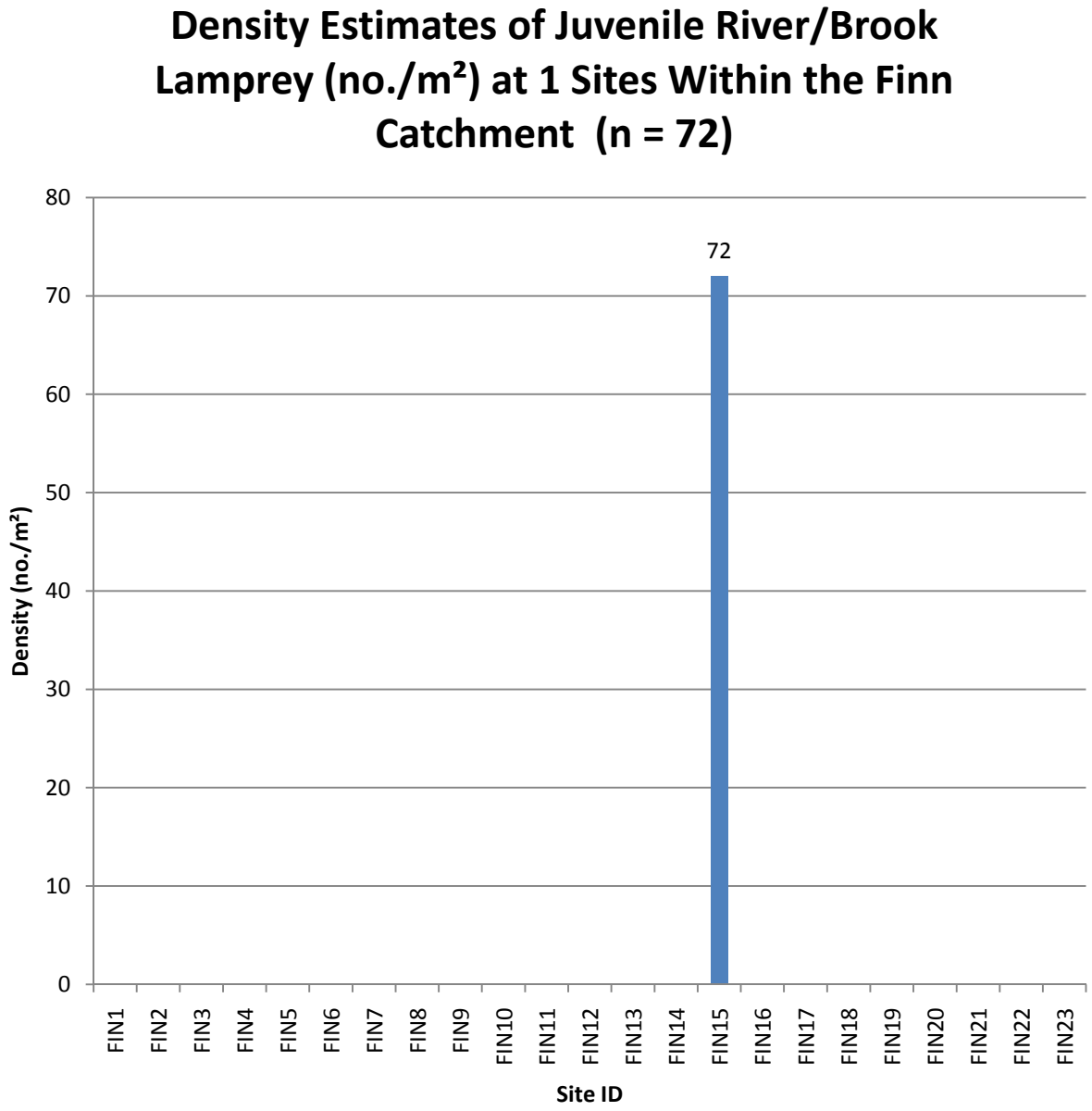

Figure 25. Juvenile River/Brook lamprey density estimates from the 23 sites surveyed within the Finn catchment, 2010.

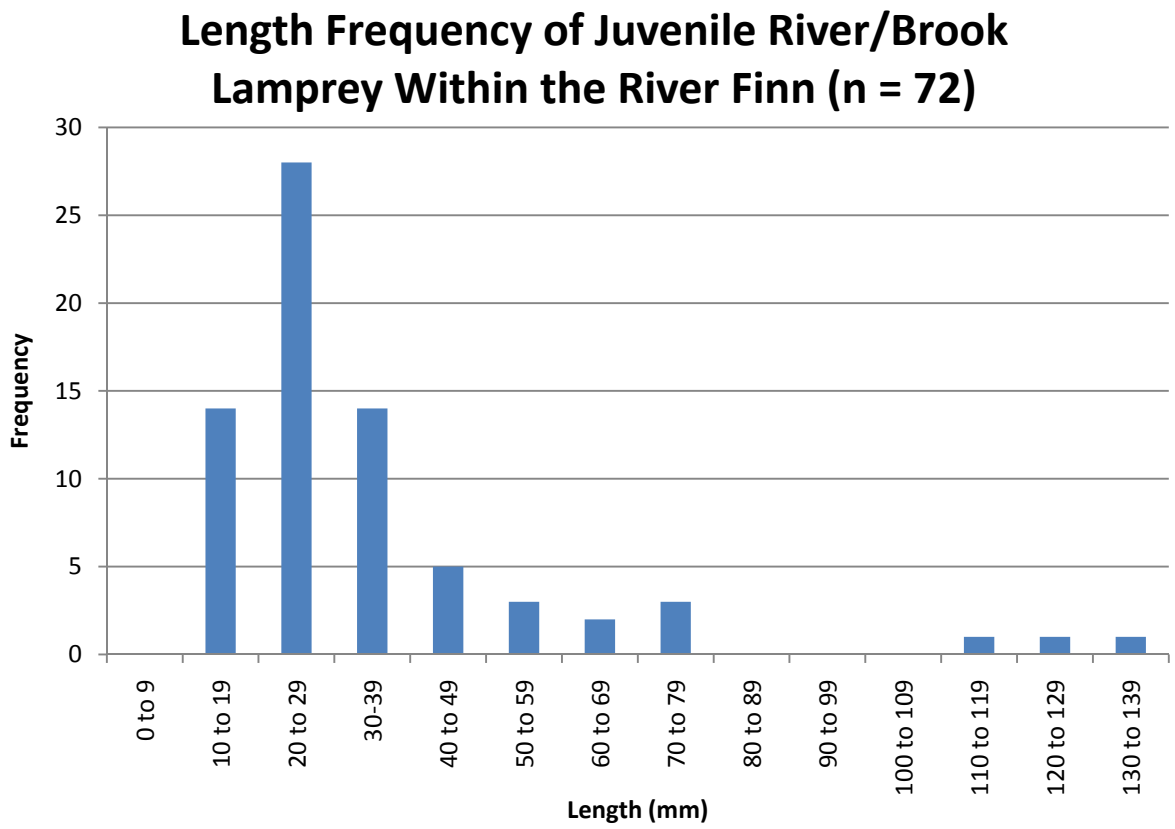

Fig 26. Length frequency distribution of all juvenile River/Brook lamprey caught within the River Finn, 2010.

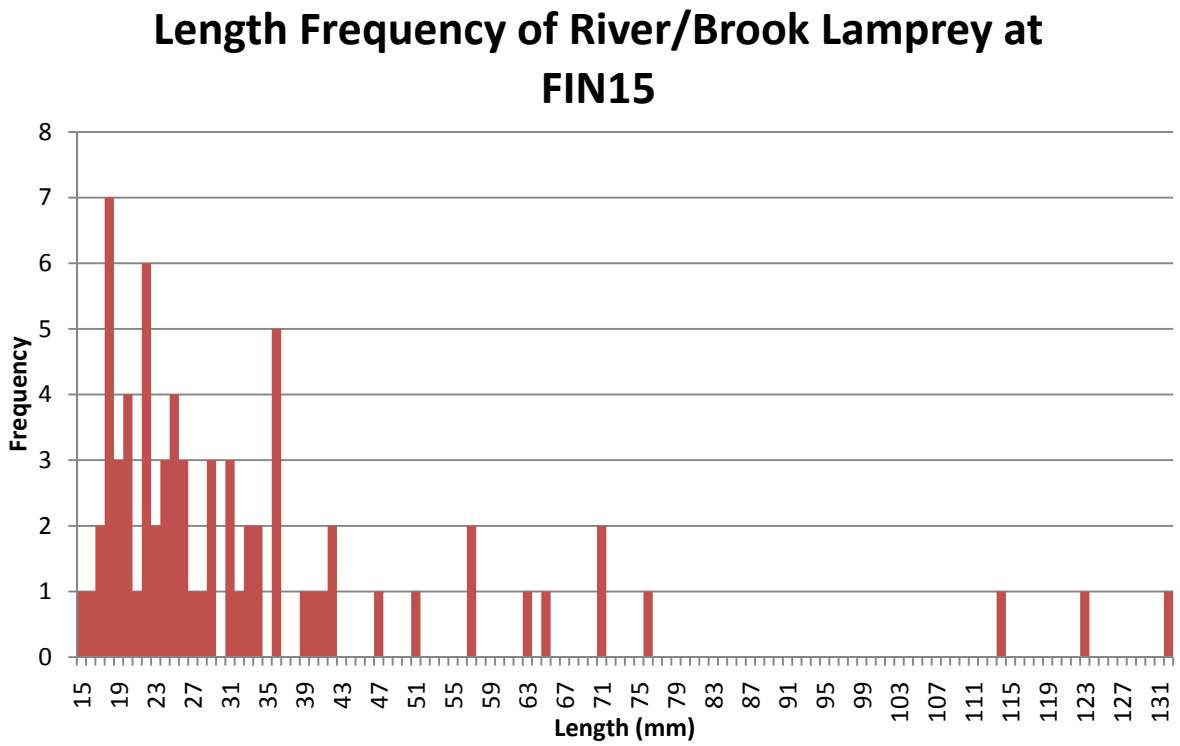

Fig 27. Length frequency distribution of River/Brook lamprey caught at all sites within the Finn catchment during the 2010 survey.

Lamprey abundance classification can be conducted in two ways, both methods classify the density of ammocoetes in order to establish the relative condition of lamprey populations within rivers. The first method is a density estimate based on catchment wide surveys including a diversity of habitats. The second method is based on density estimates within optimal habitat. Both methods are presented below for the Deele and Finn catchments for river/brook lamprey ammocoetes and sea lamprey ammocoetes.

At a catchment perspective mean minimum population densities of river/brook lamprey ammocoetes within the Deele catchment at 12 sites was 5.6/m², no sea lamprey ammocoetes were recorded within the Deele catchment. The targets for compliance with favourable conservation status under the Habitats Directive as outlined in Harvey and Cowx, 2003 is >2/m² for river/brook lamprey ammocoetes and 0.1/m² for sea lamprey ammocoetes.

Within optimal habitat in the Deele catchment (four sites) minimum population densities of river/brook lamprey ammocoetes were 16.8/m². The targets for compliance with favourable conservation status under the Habitats Directive as outlined in Harvey and Cowx, 2003 are >10/m² for river/brook lamprey ammocoetes and 0.2/m² for sea lamprey ammocoetes.

Both methods are in agreement that the Deele catchment is deemed to be meeting favourable conservation status for river/brook lamprey and is in unfavourable condition for sea lamprey.

It should be noted that the Deele catchment is not a designated Special Area of Conservation.

At a catchment perspective mean minimum population densities of river/brook lamprey ammocoetes within the Finn catchment at 23 sites was 3.1/m², no sea lamprey ammocoetes were recorded within the Finn catchment. The targets for compliance with favourable conservation status under the Habitats Directive as outlined in Harvey and Cowx, 2003 is >2/m² for river/brook lamprey ammocoetes and 0.1/m² for sea lamprey ammocoetes.

Within optimal habitat in the Finn catchment (three sites) minimum population densities of river/brook lamprey ammocoetes were 24/m². The targets for compliance with favourable conservation status under the Habitats Directive as outlined in Harvey and Cowx, 2003 are >10/m² for river/brook lamprey ammocoetes and 0.2/m² for sea lamprey ammocoetes.

Both methods are in agreement that the Finn catchment is deemed to be meeting favourable conservation status for river/brook lamprey and is in unfavourable condition for sea lamprey.

It should be noted that the Finn catchment is a designated Special Area of Conservation under the Habitats Directive although none of the three lamprey species are site selection features.

A further assessment was made of the demographic structure of the lamprey ammocoete populations of the Deele and Finn catchments Figs 20-27. Different age class contribution towards the population can be assessed by analysing the length frequency distributions outlined above. Data gathered from the Deele populations showed at least two and possibly up to four age groups/cohorts were present in the population. Data gathered from the Finn population showed at least two and possibly three cohorts were present. It is recommended that in order to achieve favourable conservation status, where abundant River/Brook lamprey ammocoete populations should have at least two age classes in the populations samples from optimal habitat.

With reference to distribution compliance with favourable conservation status should be recorded if there is no decline in distribution from the current or historical pattern.

Fig 28. 0+ (young of the year) River/Brook lamprey ammocoet

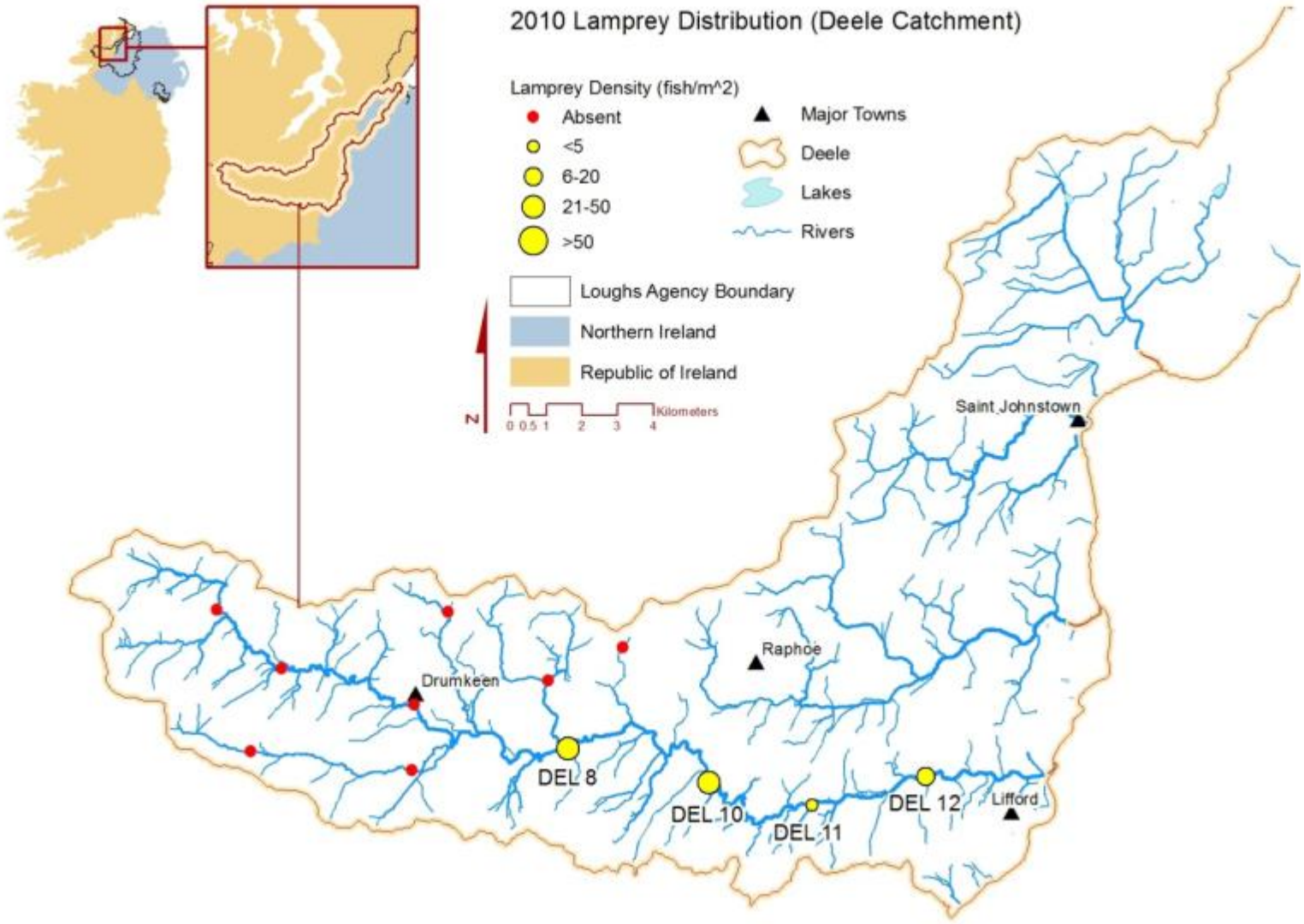

Fig 29. Juvenile River/Brook lamprey distribution and density within the Deele catchment, 2010 * Note no sea lamprey ammocoetes were caught during the survey

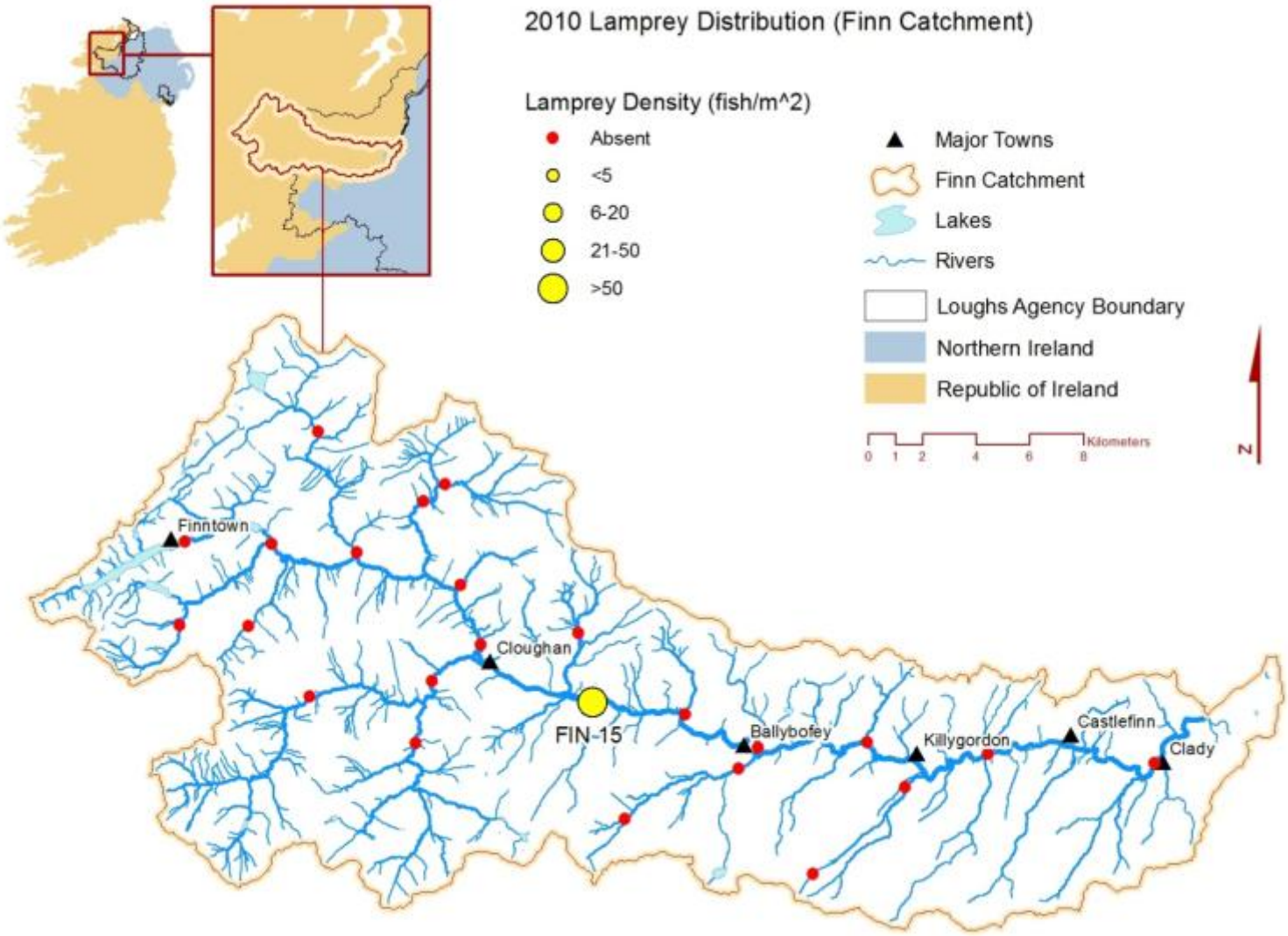

Fig 30. Juvenile River/Brook lamprey distribution and density within the Deele catchment, 2010 * Note no sea lamprey ammocoetes were caught during the survey

4.0 Discussion

The status of lamprey ammocoetes within the Deele and Finn catchments is discussed in this section. All ammocoetes found in the current study were either River or Brook lamprey with no sea lamprey ammocoetes recorded. The predominance *of Lampetra* spp is consistent from other studies in Ireland. The absence of anadromous sea lamprey ammocoetes and the inability to distinguish between River and Brook lamprey ammocoetes means that it is not possible to identify the extent of anadromous lamprey migrations in the Deele and Finn catchments. Further investigation involving netting surveys, additional electrofishing surveys, barrier surveys, redd counts and direct observation at spawning time would be required to ascertain this.

It has been suggested that sea lamprey ammocoetes may utilise deeper water habitats which are not covered by the current sampling methodology. APEM conducted lamprey surveys in Scotland and discovered greater utilisation of sediments in deeper pools by sea lamprey ammocoetes than by river/brook lamprey ammocoetes. APEM presented some preliminary findings at the Institute of Fishery Management annual conference in 2010.

Benefits of the current sampling methodologies include that it is relatively easy to conduct. Development and utilisation of suction sampling techniques for deeper habitats would add significant complexity to these surveys.

The present study did not identify juvenile lamprey at the majority of sites within the Deele and Finn catchments. This could be for a number of reasons including lack of optimal habitat, altitude, limited/no access for anadromous species, gradient and flow characteristics. The most significant of these is the lack of suitable fine sediment deposits. In both catchments most appropriate habitat may be in deeper pool areas which could not be sampled using the existing methodology.

From the current study it is possible to say that within the Finn catchment that there is extremely limited distribution within the habitats surveyed while in the Deele catchment distribution is limited to the lower reaches where suitable habitat is available and accessible.

A barrier to migration assessment should be conducted within the Finn and Deele catchments to assess the accessible area to migratory lampreys and any necessary easements made. The absence of sea lamprey ammocoetes could also be impacted by manmade obstructions/barriers such as weirs. Sea lamprey cannot jump like salmonids and can only pass certain obstructions if flows and gradient permit. This may lead to irregular recruitment or no recruitment.

Adult sea lamprey have been observed spawning and been caught in a Rotary Screw Trap on the River Finn below the first weir where there is suitable spawning and juvenile substrate.

Insensitive drainage programmes or de-silting of peripheral waterbodies with no obvious fishery interest may also have an impact on the abundance and distribution of all lamprey species. These areas always have fishery potential and should be afforded consideration when developing drainage maintenance schedules.

For a channel to successfully function as suitable habitat for lamprey it must contain a balance of the niches required by all the life history stages. For migratory forms unimpeded access is required. Spawning habitat and appropriate fine sediment deposits should be available throughout the catchment (King, 2006). The current study has highlighted a limited capacity for the Finn and Deele catchments to function as good habitat for all the life history stages of lamprey.

5.0 Recommendations

- Conduct two phase surveys to maximise potential for locating positive habitats.
- Follow up surveys during the 2011 spawning season to identify actively utilised habitats.
- Expand juvenile abundance and distribution surveys out to other catchments within the Foyle and Carlingford areas, prioritising SAC catchments.

- Regularly update records of lamprey within the Foyle and Carlingford areas into the GIS spatial database for lampreys created as part of the current project.

- Conduct direct observation/redd counting in areas of suitable habitat at spawning time.

- Conduct netting surveys at migration time to ascertain presence of anadromous lamprey.

- Develop and conduct tests in deeper pool areas using some form of suction sampling to assess distribution of sea lamprey ammocoetes.

- Investigate the potential for conducting tagging studies to assess the extent of migrations and habitat utilisation.

- Develop and promote sensitive catchment management practices specific to lamprey populations including advice to drainage authorities carrying out channel maintenance.

- Develop education materials for drainage authority personnel and sub contracted operatives.

- Understand the potential to conserve and protect lamprey populations for their biodiversity value and ability to provide ecosystem services.

- Understand the significant potential to obtain EU funding for relevant conservation projects within the Foyle and Carlingford areas incorporating lamprey conservation as a component.

- Raise awareness and understanding of lamprey populations of the Foyle and Carlingford area.

- Develop index reaches to conduct redd counts and spawning observations.

- Develop fish passage where appropriate.

6.0 Conclusions

The current study has concluded that River/Brook lamprey populations within the Deele and Finn catchments are in favourable conservation status and that sea lamprey populations are not meeting favourable conservation status. As outlined above there may be issues regarding site selection and sampling techniques for sea lamprey ammocoete habitats. As further studies are conducted within the Foyle and Carlingford areas comparisons will be made with the Deele and Finn surveys and if necessary changes to the sampling methodology made.

Reporting on the conservation status of designated fish species in river SAC's is a statutory requirement for member states of the European Union. Protocols and methodologies developed as part of the LIFE in UK Rivers Project should act as a generic framework for condition assessment in the UK and other EU Member States (Cowx et al, 2008). This report is based on surveys conducted using compliant survey methodologies, but should not be interpreted as a full site condition assessment. Inland Fisheries Ireland are the formal reporting authority for Habitats Directive site fish conservation status reporting and as such this report should be treated as a provisional conservation status assessment for Lamprey in the Deele and Finn catchments, Co Donegal.

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8.0 References

Cowx, I.G., Harvey, J.P., Noble, R.A. and Nunn, A.D. (2009) Establishing survey and monitoring protocols for the assessment of conservation status of fish populations in river Special Areas of Conservation in the UK. *Aquatic Conservation: Marine and Freshwater Ecosystems* **19**, 96-103

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.

Igoe, F., Quigley, D.T.G., Marnell, F., Measkell, E., O'Connor, W. and Byrne. (2004) The sea lamprey Petromyzon marinus (L.), River Lamprey Lamprtra 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*, Vol. 104B, No 3, 43-56

Kelly, F.L. & King, J.J. (2001) A review of the ecology and distribution of three lamprey species, *Lamnpetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): A context for conservation and biodiversity considerations in Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy*, Vol. 101B, No. 3, 165-185

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.

Kurz, I. & Costello, M.J. (1999) An outline of the biology distribution and conservation of lampreys in Ireland. Irish Wildlife Manual No. 5.