A Survey of Juvenile Lamprey Populations in the Boyne Catchment

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AN ROINN COMHSHAOIL, OIDHREACHTA AGUS RIALTAIS ÁITIÚIL
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William O'Connor

ecofact
ENVIRONMENTAL CONSULTANTS

Ecofact Environmental Consultants Ltd.
Tait Business Centre,
Dominic Street,
Limerick City,
Ireland.

t. +353 61 313519
f. +353 61 414315
e. ecofact@iol.ie

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EXECUTIVE SUMMARY

- Three indigenous species of lamprey occur in Ireland; the non-parasitic, resident brook lamprey *Lampetra planeri*, the parasitic, anadromous river lamprey *Lampetra fluviatilis* and the sea lamprey *Petromyzon marinus*. All three species are listed on Annex II of the European Union Habitats Directive (92/43/EEC). This Directive requires the Irish Government to designate Special Areas of Conservation (SACs) and to maintain the favourable conservation status of these species.

- As part of ongoing assessments of Annex II species in Ireland, the National Parks and Wildlife Service (NPWS) commissioned a survey of juvenile lamprey populations in the Boyne catchment. This survey was undertaken by Ecofact Environmental Consultants Ltd. during the period July to September 2005.

- A total of eighty-seven sites were sampled using semi-quantitative electrical fishing methods. Quantitative assessments were undertaken at an additional four sites. Physical habitat measurements were also recorded at each survey site.

- The current survey has confirmed that significant populations of river/brook lampreys occur throughout the River Boyne catchment. It is likely that populations in the lower reaches of the river include *Lampetra fluviatilis* populations while *Lampetra planeri* is likely to be the dominant species in more up-river areas. Sea lampreys were not confirmed during the current survey.

- During the current study lampreys were identified on the basis of their external pigmentation characteristics. Ammocoetes with characteristic brook/river pigmentation were found throughout the catchment while larvae with an unusual pigmentation type were found in the middle and upper reaches of the Boyne and tributaries but not in the lower Boyne and Kells Blackwater sub-catchment. The unusual pigmentation type observed was somewhat similar to that described previously for sea lampreys and this caused confusion when examining lampreys under field conditions. Further detailed investigations involving counting myomeres concluded that all the lampreys present were brook/river.

- The Boyne catchment was subjected to a major arterial drainage scheme during the 1980s and the impact of this scheme on lamprey production in the catchment is thought to have been quite significant. The availability of optimal lamprey nursery habitat is restricted in many areas of the catchment because of this drainage scheme.

- The lower reaches of the Boyne and the middle reaches of its tributary the Kells Blackwater were not directly affected by the drainage works. These areas have a good abundance of physically ideal juvenile lamprey habitats. Existing lamprey habitat in the catchment is under threat from pollution and drainage maintenance.

- Lampreys were present at 70 out of the 91 sites investigated (77%). Mean minimum densities of river/brook juveniles recorded was 5.16 ± 2.43 juvenile lampreys per m^2. These minimum densities were significantly higher that those recorded recently in other NPWS surveys of Irish rivers (i.e. Moy and Feale).

- Population structure varied between different sub-catchments. However, most sites had two or more age classes present. Evidence of recent recruitment was found on most channels investigated; with the notable exception of the Kilwarden River which flows through Kinnegad. Standard length of juvenile lampreys recorded ranged from 0.5 cm to 17.7 cm. The efficiency of capturing young of the year larvae (YOY) was considered to be low due to their small size and poor water quality conditions in most areas.

- The main lamprey populations in the River Boyne are currently protected within the existing SAC boundary area and no recommendations are made to extend the boundary area.

1.0 INTRODUCTION

Three species of lamprey occur in Ireland: brook lamprey *Lampetra planeri*; river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*. All three Irish lamprey species are listed on Annex II of the European Union Habitats Directive (92/43/EEC). This directive legally protects each of these species in designated Special Areas of Conservation (SACs) and requires the monitoring and protection of lamprey species coupled with the conservation and maintenance of their preferred habitat. The National Parks and Wildlife Service (NPWS) of the Department of Environment, Heritage and Local Government are currently undertaking a programme of surveys in all of the SACs designated for lampreys. Since 2000, catchment-wide studies have been completed on the Slaney and Munster Blackwater, the Feale, the Moy and the Barrow.

The current survey concerns the Boyne catchment and was undertaken during the period July to September 2005. The assessment involved electrical fishing investigations at 91 sites throughout the catchment. The aims of the current investigation were:-

- To establish the abundance and distribution of lamprey species in the River Boyne catchment;
- To determine the age structure of the populations present in order to assess production levels;
- To determine the distribution of the main nursery sites in relation to habitat types and vegetation to facilitate decisions with regard to habitat management.

This study was undertaken by Ecofact Environmental Consultants Ltd. on behalf of NPWS.

2.0 STUDY AREA

2.1 The Boyne catchment

The Boyne (Figure 1) is one of Ireland's larger river catchments. It rises near Edenderry on the borders of Counties Offaly and Kildare and flows in a north-easterly direction for 112 km before entering the Irish Sea at Drogheda. Together with its tributaries, it drains a catchment of approximately 2,500 km^2. It flows through the fertile plains of Royal Meath and its valley is rich in archaeological remains. The prehistoric burial chambers at Newgrange and the numerous ruins of medieval castles and abbeys bear testament to a colourful history (O'Reilly 2002). It is one of the country's premier game fisheries and both the main river and its tributaries offer a wide range of fishing for spring salmon, grilse, seatrout and brown trout. In all, the Boyne offers 213 km of angling water (O'Grady 1998).

Most of the Boyne catchment is underlain by limestone-based glacial till (O'Grady 1998). The Boyne has eleven major tributary sub-catchments and drains a mainly lowland area. Consequently all sub-catchments are fed by percolating ground water to a greater extent rather than by runoff. Channel gradients in the main stem and primary tributaries are all within 1-2 m/km (O'Grady, 1998). There is very considerable variation in river channel bed type - sand, gravel, gravel/cobble, sheet rock and boulder clays are evident over long sections of channel (O'Grady 1998). In many areas of cobble/gravel bed type, extensive calcification of bed materials is evident resulting in a solidified encrusted bed. Farming practices in the catchment include dairy, beef production and tillage. Since the 1980's sheep production has also become important. Industrialisation in the catchment is limited in extent and confined principally to the two larger towns; Drogheda and Navan.

The Environmental Protection Agency (EPA), and its predecessors (An Fóras Forbatha, Environmental Research Unit), has assessed water quality (chemical and biological) in the Boyne catchment since 1971 as part of the National Water Quality Monitoring Programme (Toner *et al* 2005). A summary of the overall results for the Boyne catchment (hydrometric area 7) during the period 2001-2003 are presented in Table 1. Overall, water quality in the Boyne catchment is of an unsatisfactory status. Only 23% of the river channels surveyed during the period 2001-2003 were classified as being Class A or unpolluted. Indeed, just three of the eighteen sites surveyed on the main channel during 2003 achieved a 'Fair' (Q4) water quality rating.

Extensive electrofishing operations were carried out in the Boyne catchment during the mid-1980s by the Central Fisheries Board (O'Grady 1998). However, these surveys were focused on assessing salmonid populations and little information was collected regarding lamprey populations. These surveys indicated the presence of at least 14 fish species: salmon, trout, pike, perch, stoneloach, gudgeon, minnow, rudd, bream, tench, eel, stickleback, flounder and lamprey (unspecified). Roach have been present in the catchment since the 1980's (Fitzmaurice 1971). The surveys indicated that fish stocks in the riverine channels within the catchment were dominated by juvenile salmon, brown trout and minnow populations. Stoneloach and gudgeon were found to be widely distributed in small numbers throughout the main channel and all of its tributaries. The cyprinid species perch were found to be largely confined to small lakes within the catchment. O'Grady (1998) reported that spawning sites for both salmon and trout are confined principally to the tributaries as there are very limited gravel deposits in the main channel. However, sub-tributaries in the catchment were generally not of importance in fisheries terms - unlike catchments such as the Moy where even first order tributaries are important for the production of juvenile salmonids. O'Grady (1998) states that the tributaries function as nursery areas for salmonids and the larger of these channels, and the main Boyne channel, support substantial populations of adult brown trout and salmon parr. Salmon angling areas are largely limited to the main Boyne downstream of Navan and the lower reaches of the Kells Blackwater. Adult salmon seldom move upstream of this point in the channel until late in the year, after the angling season (O'Grady 1998; O'Reilly 2002).

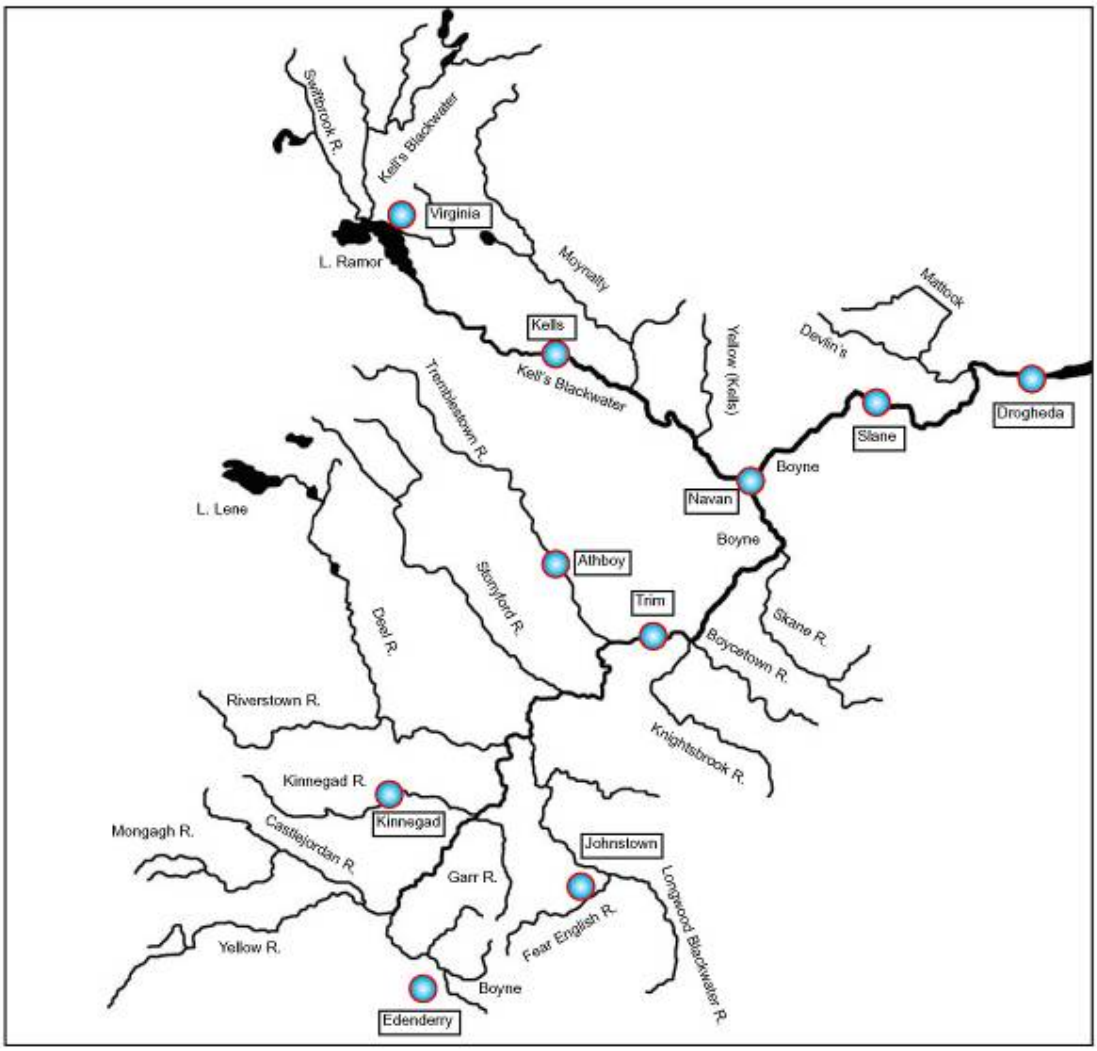
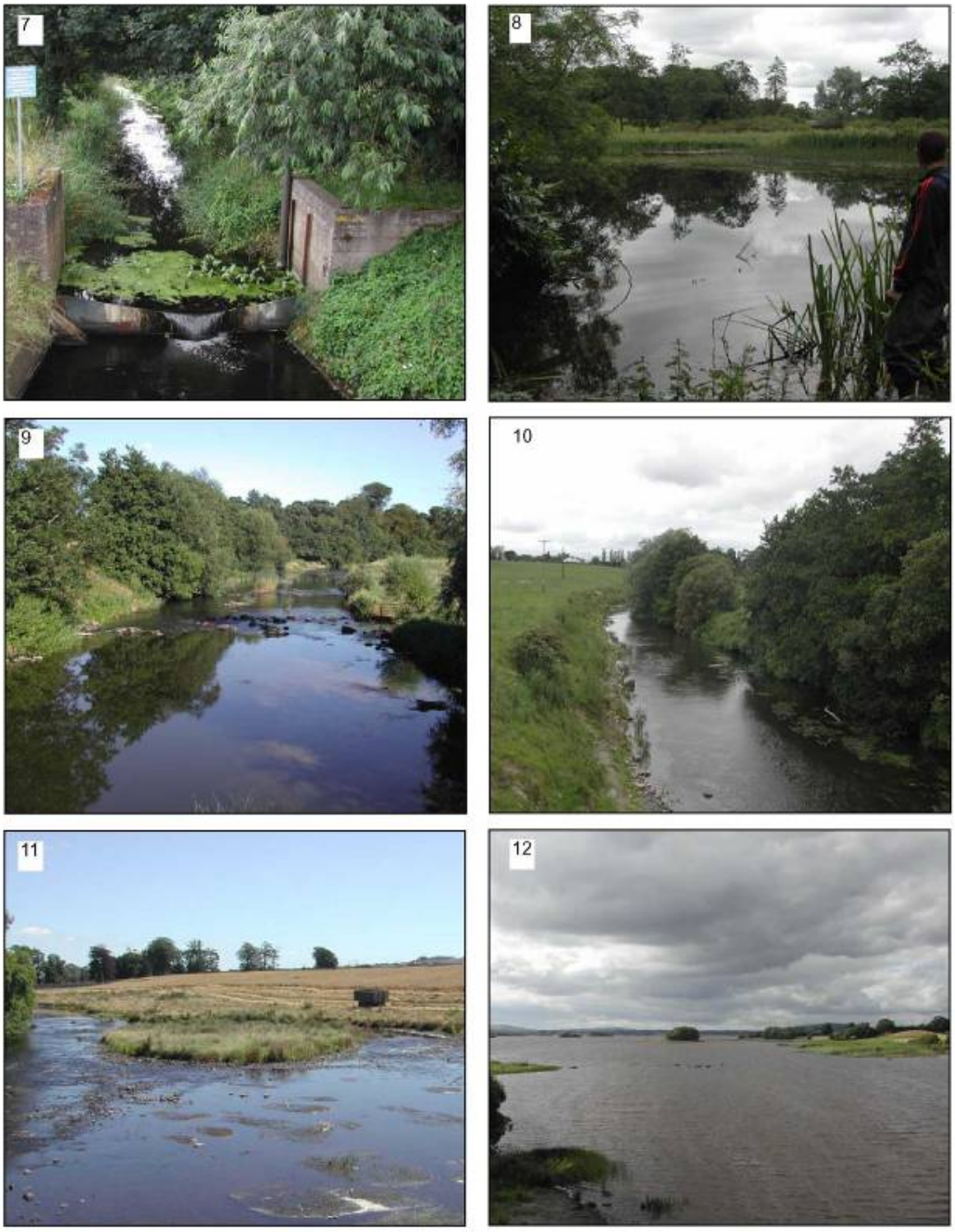


Figure 1 The Boyne catchment showing the main tributaries and important towns in the catchment.

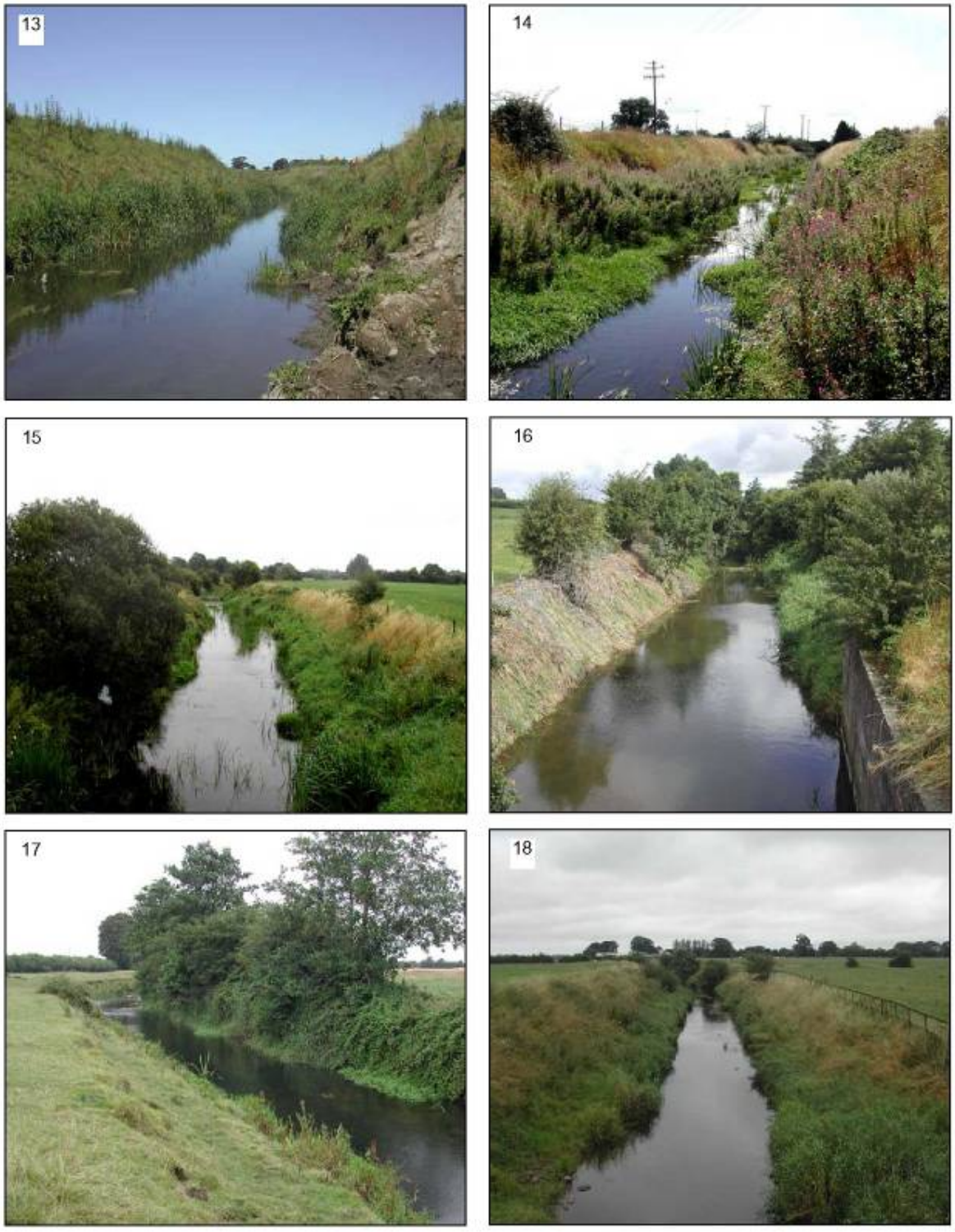
Table 1 Summary of water quality results from EPA hydrometric area 7 showing overall results for the Boyne catchment. Data is from EPA biological surveys during the period 2001-2003 (adapted from Toner *et al.* 2005).

Catchment	Class A	Class B	Class C	Class D	Total (km)
Boyne (km)	109.5	221.0	148.5	0.0	479.5
Boyne (%)	23	46	31	0	

Plates 1-6 (1) The lower River Boyne near Drogheda, (2) The lower River Boyne with heavy macrophyte growth near Newgrange, (3) at Slane weir, (4) The Boyne at Navan immediately upstream of the Kells Blackwater confluence, (5) The Boyne passing Trim Castle, (6) Scarriff Bridge in the middle reaches of the Boyne with the pre-drainage channel and bridge arches visible.



Plates 7-12 (7) The upper River Boyne near Edenderry, (8) The source of the Boyne, (9) The lower reaches of the Kells Blackwater, (10) arterially drained section of the Kells Blackwater below Kells, (11) undrained section of the Kells Blackwater upstream of Kells, (12) Lough Ramor near the outflow of the Kells Blackwater.



Plates 13-18 (13) The lower reaches of the Moynalty River, (14) The Kilwarden/Kinnegad River, (15) The lower reaches of the Yellow River, (16) heavily channelised section of the Deel, (17) The Tremblestown River immediately upstream of the Boyne confluence, (18) The lower reaches of the Stonyford River.

O'Grady (1998) reported that three major ecological impacts on the Boyne catchment have occurred in recent times. These are:-

- Excavation of peat lands in the headwater area of the catchment to fuel power stations;
- The 1980's arterial drainage scheme which affected virtually the entire catchment;
- The onset of serious eutrophication problems on Lough Ramor in the Kells Blackwater sub-catchment.

The excavation of the peat bogs in headwater areas led to a runoff of fine peat silt particles causing siltation of the headwater tributaries and excessive growth of the reed *Phalaris arundinacea* on these lateral silt beds. This led to a narrowing and deepening of the stream channels and clogging of spawning gravels with peat silt; particularly in the catchment area above Trim (O'Grady 1998). The second major event to impinge on the system was the implementation of an arterial drainage programme throughout the catchment. This programme commenced in 1969 and continued until 1985 (O'Grady 1998). Over this 17- year period one tributary and a section of the Boyne itself, on average, were drained annually. The only major section of this catchment which was not drained was the lower region of the main Boyne channel - from Navan downstream. An overlapping of dredging operations in the main channel from year to year was a design feature of the scheme. This ensured that silt that had accumulated at one point in the main channel as a consequence of dredging upstream in one year could be removed the following year.

However, O'Grady (1998) reports that the drainage scheme may have improved salmonid production in the catchment. He concluded that this was due to (a) the restoration of a natural river form in the middle reaches of the main channel as a result of the removal of a series of large weirs and (b) the post-drainage fishery enhancement programmes. The lower reaches of the main Boyne channel, from Navan to Drogheda, was not subject to arterial drainage and this coupled with the lengthy nature (17 years) of the drainage scheme was also probably advantageous in terms of maintaining salmonid production (O'Grady 1998).

The impact of the arterial drainage scheme on lampreys is difficult to ascertain due to the absence of any information on lampreys in the river prior to the works. Dredging of the river was likely to have resulted in the physical removal of a significant proportion of lamprey larvae present and the almost complete destruction of existing lamprey spawning and nursery habitats. Since the 18th century, 11 large stone-built weirs were constructed in the middle reaches of the Boyne to provide a power source for corn mills (O'Grady 1998). These structures impounded flows resulting in the accumulation of large quantities of silt in the channel. All of these weirs and the major silt deposits were removed in the course of drainage operations. Although the removal of the weirs has potentially improved conditions for migrating lampreys on the river, it is likely that the removal of these silt beds had a serious impact on resident lamprey populations. The excavated channel beds are now used by lampreys, however, these areas were likely to be unstable for some time after the works and the amount of silt present is much reduced from before. Indeed, data compiled on the physical nature of the river bed during 1986-1988 confirmed the absence of significant silt deposits on the bed in the middle and lower reaches of the river at this time (O'Grady 1998). Drained rivers have a much reduced lateral heterogeneity and a lower availability of flow refugia and backwater habitats than undrained rivers and this can be expected to restrict lamprey production. Ongoing maintenance of channels (i.e. removal of silt accumulations etc.) further threatens lamprey populations in the Boyne catchment. However, the Office of Public Works (OPW) now consults with NPWS in advance of river works so it will be possible to avoid or mitigate impacts in the future.

3.0 METHODOLOGY

3.1 Selection of Sites

Sections of river channel near existing EPA water quality sampling stations were assessed for the presence of juvenile lamprey habitat during an initial walkover survey. Juvenile lamprey habitat was identified from the descriptions given in Maitland (2003). Such sections generally had fine-grained bed material and a water depth suitable for wading. When available, an area of up to 10 m^2 was selected for surveying in the vicinity of each EPA water quality station. In many areas it was difficult to locate suitable larval lamprey habitat. In some cases fragments of habitats spread over more than 100 m were assessed as a single site.

3.2 Electrical Fishing Assessment

Sites were investigated using electrical fishing. This is a well-established technique for sampling fish populations in freshwater (Lagler 1978; Reynolds 1983; Bohlin *et al.* 1990). When an electric current is passed through water, a fish within the electrical field will turn and swim towards the anode (known as the anodic effect). This mechanism is referred to as electrotaxis and fish may be stunned (electronarcotisation) as it reaches the anode. A dip net is then used to retrieve the fish from the water.

A Smith-Root LR-24 portable electrical fishing unit was employed during this survey. The LR-24 set is powered by a 24v sealed battery and delivers a 50 to 990 Volt output in 5 volt steps. This machine can automatically set voltage and power to the pertaining site conditions (conductivity, water depth). This automatic set up routine was used during the current survey to ensure that a constant effort was applied at each site. The anode handle consists of fibreglass and is equipped with a safety switch, a steel ring shaped electrode (diameter 300 mm). The steel ring electrode was fitted with a fine mesh net (1 mm) to facilitate lamprey collection. The cathode, consisting of three wires, was allowed to trail behind the operator. The operators (2 persons) wore insulated chest waders. The machine was secured on the back of one operator who also held the anode. The assistant (second operator) held an insulated dip net (mesh size 1mm; 40 cm x 40 cm frame, handle length 182 cm) for collecting lampreys that failed to be captured by the operator.

The sampling approach permitted the recording of presence/absence data, as well as facilitating collection of population structure and minimum density data. Sampling areas at each site were fished in a zigzag manner. The area fished at each site varied depending on the extent of fine-grained bed material and suitable water depth available. A fishing operation started with the gear constantly 'on' followed by a regular on/off sequence. While the gear is 'on' the anode was slowly pulled backwards in the water to cause lampreys to emerge from burrows as a result of electro-taxis. This procedure was repeated throughout the operation. By keeping the anode 1-15 cm above the sediment and pulling the anode backwards, the number of lampreys stunned within the substrate was reduced. Captured lampreys (and other fish) were removed quickly using the anode net or dip net and placed into a container of river water. Surveys were completed after 20 minutes continuous fishing (or earlier if large quantities of lampreys were encountered or if there was a paucity of suitable and accessible habitat at the site). After each survey was completed, all captured fish were anaesthetised using a solution of Phenoxyethanol. Bycatch species captured at each site were counted. Lampreys were measured to the nearest millimeter (standard length), weighted to the nearest 0.1g and identified using the keys given in Gardiner (2003). The following equipment was utilised in the assessment:-

- Portable bench and chair
- Soft fine-meshed net
- Bendy stainless steel tweezers
- Measuring board
- Ohaus Portable scales (0.1g)

- Smooth white Formica board
- Headband magnifier and hand lenses
- Vernier micrometer.

Subsequent to examination, all fish were allowed to recover in a container of river water. All fish were released alive and spread evenly over the sampling area. Results of the investigations are presented using two CPUE indices (lamprey number m^{-2}, and lamprey weight (biomass) m^{-2}.

3.2.1 Quantitative Electrical Fishing Assessment

A total of four sites were selected for quantitative assessment. These sites were closed off using heavy duty fine mesh stop nets with bottom weights and floats. These sites were at least 5 m in length and 1 m wide, depending on the characteristics of the site. Electrical fishing within the enclosures was the same as described above. Three passes were made in each enclosure, with a fifteen-minute rest period after each sampling effort. Fish from each pass were retained separately for identification, enumeration and measurement of length and weight. On completion of the electrical fishing, a steel framed net was used to scrape through the upper 50-100 mm of sediment in each enclosure. This process served to ascertain the presence of further juveniles, including the very small young-of-the-year. Minimum densities were calculated using the Leslie-Davies Method. Results of the electrical fishing investigations are presented as a minimum density estimate (number and biomass m^{-2}).

3.3 Description of Sites

Following completion of the fishing, the dimensions and physical habitat characteristics of each site were recorded. The following general physical habitat characteristics of the stretch of river where the site was located were recorded: -

- Wetted width (m)
- Bank height (m)
- Mean depth (cm)
- Maximum depth (cm)
- Bank cover (%)
- Canopy cover (%)
- Bank slope (degrees)
- Riffle (%)
- Glide (%)
- Pool (%)
- Vegetation cover (%)
- Shade (%)
- Rock substrate (%)
- Cobble/Rubble substrate (%)
- Gravel substrate (%)
- Fine substrate (%)
- Flow (m sec-1)
- Bank slope (degrees)

Flow measurements were carried out using a *Geopacks* mechanical flow meter and wading rod. The following physical habitat characteristics were recorded for the area fished:-

- Mean depth (cm)
- Sand (%)
- Silt (%)
- Clay (%)
- Density (index)
- Shade (%)
- Rooted Vegetation Cover (%)
- Flow (m^3 sec^{-1})

Other general characteristics such as the presence of larger materials (cobbles etc.) and the presence of organic material were also recorded. Site photographs (of river channel and actual area fished) were taken with a 4MP Nikon digital camera and site location was recorded with a handheld GPS unit (Garmin Geko 301). Conductivity and water temperature were measured on site using an Oakton Acorn Con 5 handheld meter. Dissolved oxygen was measured at selected sites using a YSI portable meter.

3.4 Assessment of Conservation Status

Harvey & Cowx (2003) have proposed a methodology for assessing the conservation status of lampreys in British rivers using information on abundance classification, population structure and distribution. In the absence of a scheme for Irish rivers this scheme is referred to in the current report. The scheme is given as follows:-

Abundance classification

The first approach classifies the density of lamprey ammocoetes in order to define the relative condition of fish populations in rivers. This assessment is based on two measures – the first a density estimate based on optimal habitat, and the second a density estimate based on catchment-wide surveys that will include a diversity of habitats. The attributes for compliance with favourable status are tentatively set at:

Optimal habitat

- Population density river/brook lamprey ammocoetes >10 m^{-2}
- Population density river/brook lamprey ammocoetes chalk streams >5 m^{-2}
- Population density sea lamprey ammocoetes 0.2 m-2

Catchment perspective

- Population density river/brook lamprey ammocoetes >2 m^{-2}
- Population density sea lamprey ammocoetes 0.1 m^{-2}

Abundances less than these targets indicate rivers/reaches/sites in unfavourable condition. It is important that an appropriate number of sites are surveyed to account for natural spatial variation in lamprey population size in the SAC rivers under examination.

Population demographic structure

A second assessment can be made of the demographic structure of the population – that is, the contribution of different age classes to the population to demonstrate recruitment success. To achieve favourable conservation status, where abundant, river and brook lamprey ammocoete populations should have at least two age classes in the populations sampled from optimal habitat. Deviation from compliance should not occur in more than one year in three.

Distribution

Further assessment of the status of lampreys can be derived from mapping their distribution in individual SAC rivers. Compliance with favourable conservation status should be recorded if there is no decline in distribution of ammocoetes from the current, or where available, historical pattern. This distribution pattern should be linked to favourable habitat status, whereby no deterioration in habitat quality is registered.

Plates 19-24 (19-22) Electrical fishing with a Smith-Root LR-24 backpack electrical fishing unit, (23) recording site data on the middle reaches of the Kells Blackwater, (24) equipment used to examine larval lampreys; headband magnifier, measuring board, handheld balance, calipers, tweezers, white board, and portable microscope.

4.0 RESULTS

A total of ninety one sites comprising of a total of 678 m^2 were investigated using electrical fishing during the period July to September 2005. The total area fished was equivalent to 0.01 % of the 6,695,400 m^2 of total fluvial habitat present in the Boyne catchment (McGinnity *et al.* 2003). The location of all areas investigated is presented in Figure 2 and a list of the areas surveyed is provided in Appendix 1. Photographs of the river channels in the vicinity of the survey sites are also provided in the attached CD-ROM.

A total of twenty nine sites were investigated on the main channel of the River Boyne while a total of twenty one sites were located in the Kells Blackwater sub-catchment - the largest of the Boyne tributaries. The Boyne has only one significant tributary downstream of Navan – The Mattock – and four sites were investigated there. Between Navan and Trim the Skane, Boycetown and Knightsbrook rivers confluence with the Boyne. An overall total of six sites were investigated on these relatively small rivers. Upstream of Trim a total of seven tributary systems join the Boyne. The largest three of these are the Deel, Stonyford and Tremblestown sub-catchments. A total of eight, five and four sites respectively were surveyed in these river systems.

4.1 Electrical Fishing Site Characteristics

Sites investigated were located throughout the sub-catchments and were distributed at altitudes from near sea level to 101 m a.s.l. The wetted width of channels investigated ranged from 2 to 35m while depths ranged from 15 cm to >200 cm. Water quality in most of the areas investigated had been recorded as being slightly to moderately polluted by the EPA during their 2003 biological survey (Toner *et al* 2005).

The EPA have reported that the lower half of the Boyne had widespread eutrophication during 2003. An abnormally luxuriant growth of filamentous algae along with associated calcification was also recorded during the current survey downstream of Navan and on the lower reaches of the Kells Blackwater. Conductivity levels recorded during the current survey were within the range of values reported previously for the Boyne catchment by Toner *et al* (2005). Bank height of surveyed channels was generally high (mean 3.4m) reflecting the drained nature of most of the rivers in the study area. Likewise, glide habitat – a predominant feature of drained river channels - dominated many of the channels investigated. Bank erosion was apparent in several areas as a result of unstable channels resulting from the drainage history and uncontrolled access by farm animals (e.g. Boyne above Trim, Stonyford R.). The mean proportion of fine substrate in the channels adjoining surveyed areas was 21.1%.

The lowering of the river channels during the 1980s arterial drainage programme along with the removal of weirs and silt deposits along the Boyne is known to have significantly reduced the quantities of fine substrate material in the river. However, the lower Boyne and parts of the Kells Blackwater were not directly affected by the scheme and have a good diversity of lamprey microhabitats present. Peat silt eroded from bogs in the upper Boyne catchment has also resulted in the creation of secondary lamprey nursery habitats along significant sections of river.

The mean depth of the areas surveyed for juvenile lampreys was 26.7 ± 2.4 cm. Mean flow in the areas surveyed was 0.02 m^2 sec^{-1}. Almost half of the sites surveyed had no measurable flow. The overall composition of fine material surveyed at the 91 sites was 23.4% sand, 26.1% silt and 50.5% clay. A large proportion of the sites surveyed were partially shaded and rooted vegetation cover ranged from 0.0% to 70.0% (mean 24.1%). The average area fished was 7.45 m^2 (Minimum 1 m^2, Maximum 20 m^2, Standard Deviation 3.86). Areas were fished for a minimum of one minute per m^2 and up to five minutes per m^2 when significant numbers of lampreys were present.

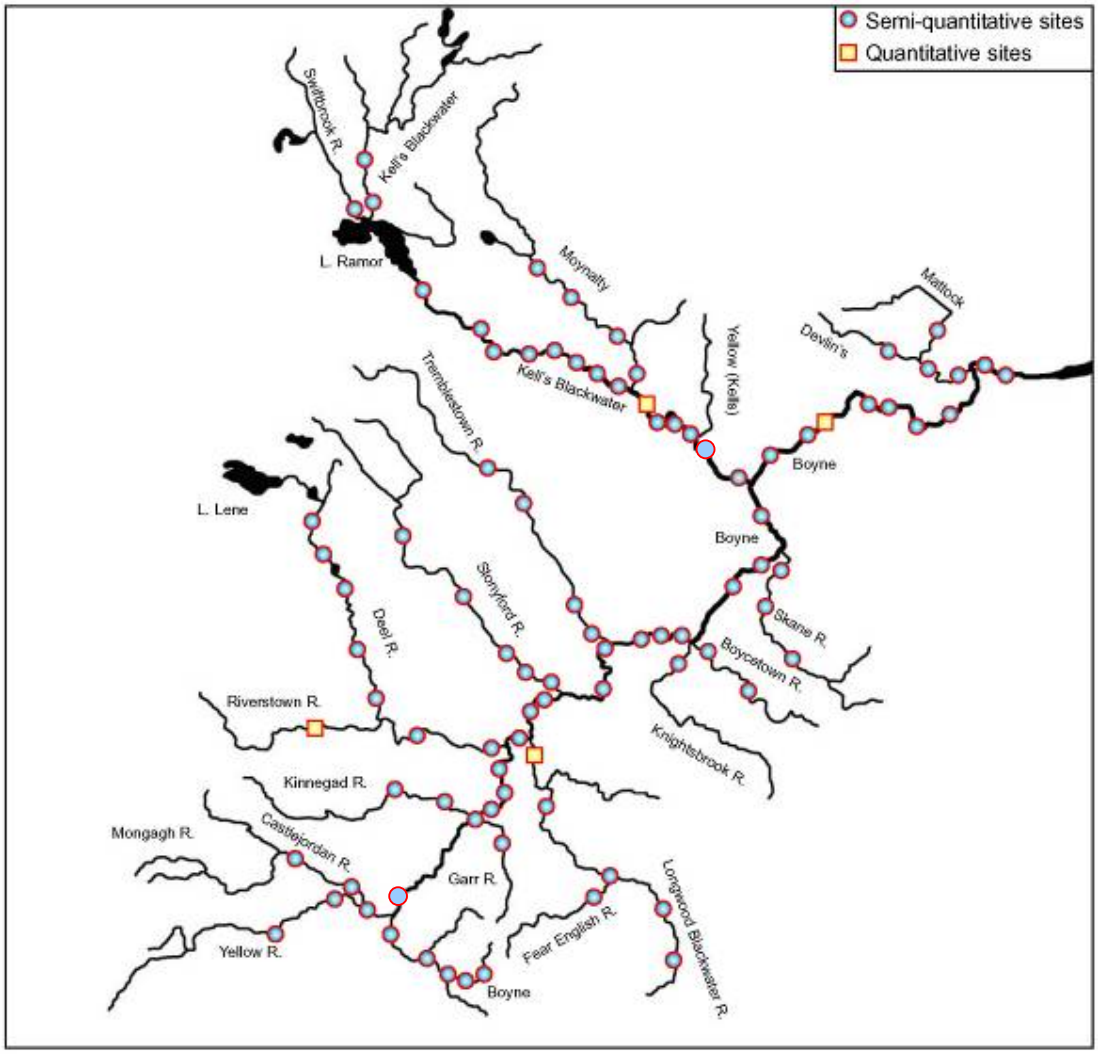


Figure 2 Locations of the 91 electrical fishing sites undertaken in the Boyne catchment during 2005. The locations of both semi-quantitative and quantitative sites are indicated.

4.2 Lamprey Catch

A total of 1,806 lampreys weighing a total of 2.754 Kg were recorded during the current survey. Lampreys were identified using the key provided by Gardiner (2003). This key is based on earlier work by Potter & Osborne (1975) which concluded that sea lamprey ammocoetes can be distinguished from those of river or brook lamprey by the different pigmentation patterns and morphology present. The key describes how in sea lamprey the entire oral hood is pigmented, although the intensity diminishes towards the lower edge of the upper lip. In contrast, in river and brook lamprey, although the upper part of the oral hood is dark and well pigmented, this does not extend as far as the edge of the upper lip. In sea lamprey, the deeply pigmented area in the caudal regions is reported to reach almost to the base of the ventral surface of the body, in contrast to river and brook lamprey. In sea lamprey, pigment spreads from the body into the caudal fin and second dorsal fin, as opposed to river and brook lamprey, where it is generally limited to a thin strand along the base of the fin, except in occasional large brook lampreys, when pigment cells could be found in the fin itself. Differences in caudal fin shape were also reported between sea lamprey and river or brook lamprey, but Potter & Osborne (1975) considered these to be only apparent in larger individuals, and never an easy diagnostic character to apply.

Trunk myomere counts were found by Potter & Osborne (1975) to be able to provide an unambiguous corroboration of identification – the counts ranged from 69–75 in sea lamprey, but only 57–66 in river and brook lamprey. Gardiner *et al.* (1995) found that all 3,723 live ammocoetes they examined from Scottish rivers could be identified to either sea lamprey, or to a river/brook lamprey category, on the basis of the criteria in Potter & Osborne's (1975) paper. In the Gardiner *et al.* (1995) study, trunk myomere counts were made on a number of brook/river and sea lamprey ammocoetes to check identifications made on the basis of visual appearance. All were reported to be within Potter & Osborne's ranges (Gardiner unpublished).

During the current study lampreys were identified on the basis of their external pigmentation characteristics as described above. Specimens with ambiguous pigmentation characteristics were retained for further laboratory examination. Ammocoetes with characteristic brook/river pigmentation were found throughout the catchment while larvae with an unusual pigmentation type were found in the middle and upper reaches of the Boyne and tributaries but not in the lower Boyne and Kells Blackwater sub-catchment. Lampreys with the unusual pigmentation type were more common in the deeper areas of the catchment.

The unusual pigmentation type observed was somewhat similar to that described previously for sea lampreys and this caused confusion when examining lampreys under field conditions. In these specimens, pigmentation extended out into the tail and ventrally on the oral hood in a similar fashion to sea lampreys. All size groups were affected. However, on examination under laboratory conditions it was clear that the pigmentation levels recorded were much less intense and the tail shape more rounded than that of sea lampreys retained from previous surveys. Further detailed investigations involving counting myomeres on retained specimens and lampreys collected during surveying of eight additional sites during the 12-14th September 2005 concluded that all the lampreys present were brook/river although a significant proportion of them were exhibiting unusual pigmentation characteristics. In Table 2 the descriptive statistics for the numbers of trunk myomeres recorded on 151 ammocoetes showing characteristic *Lampetra* sp. pigmentation and 49 showing the unusual pigmentation pattern are given. No significant differences ($p>0.001$) were observed and it was concluded that both 'groups' are brook/river lampreys. In Figure 3 the percentage distributions of trunk myomeres recorded in the two 'groups' are also shown.

It is concluded that two species of lampreys are present in the Boyne catchment: *Lampetra planeri* and *Lampetra fluvialitis*. It is not possible to differentiate between the ammocoetes of these two species in the field. No fully transformed *Lampetra* sp. juveniles were recorded during the current survey. However, some of the lampreys recorded were seen to be in the early stages of transformation. During the September assessment lampreys in later transformation stages were recorded.

Table 2 Descriptive statistics for the numbers of trunk myomeres recorded in a sample of 200 ammocoetes collected from the Boyne catchment during September 2005.

	Unusual pigmentation characteristics	Typical *Lampetra* sp. pigmentation characteristics
Mean	60.67	60.61
Standard Error	0.22	0.14
Median	61.00	60.00
Mode	61.00	60.00
Standard Deviation	1.56	1.73
Sample Variance	2.43	3.00
Range	5.00	8.00
Minimum	58.00	57.00
Maximum	63.00	65.00
Count	49	151
C.I. (95.0%)	0.45	0.28

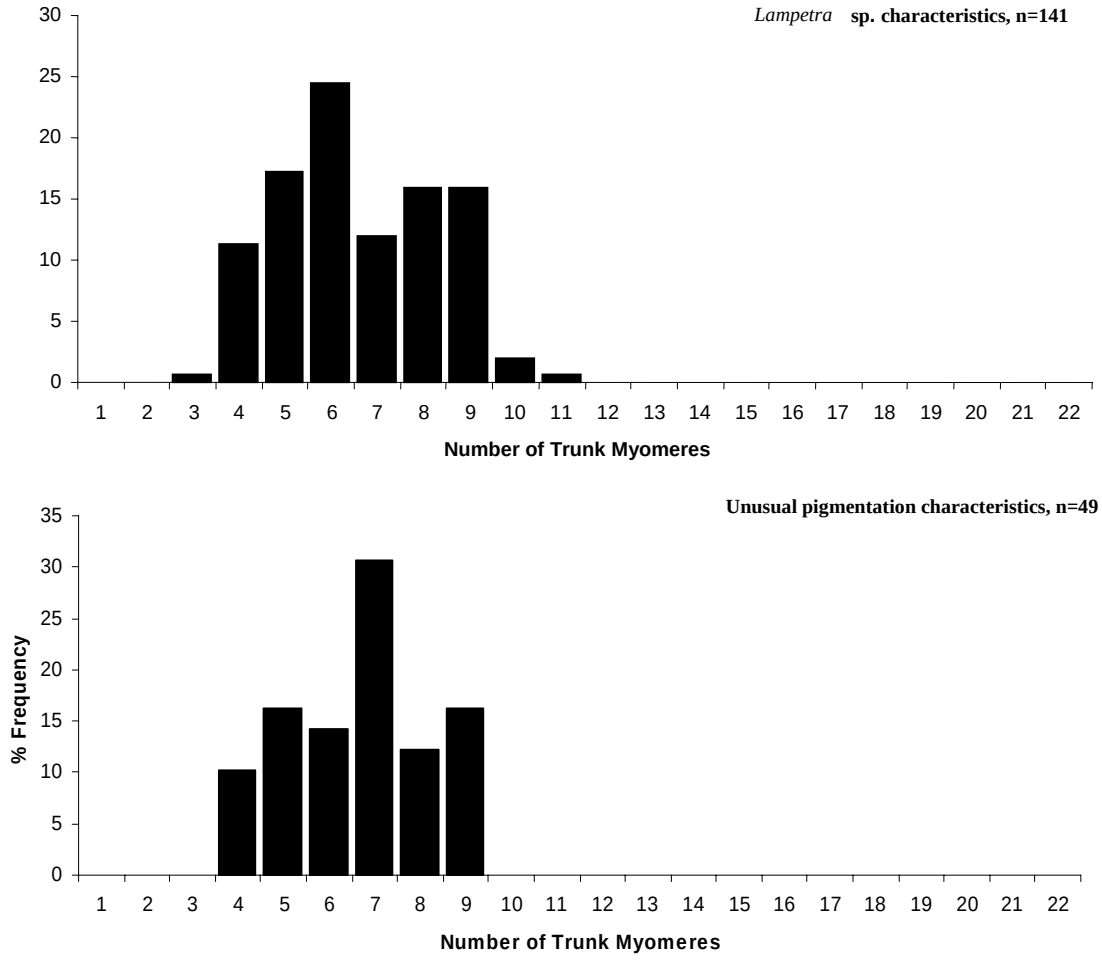


Figure 3 Percentage distributions of trunk myomeres recorded in a sample of 200 ammocoetes collected from the Boyne catchment during September 2005.

4.3 Distribution, Abundance and Characteristics of Lamprey Populations

The distribution of juvenile lampreys at the ninety one sites investigated during the 2005 survey is illustrated in Figure 4. The length percentage frequency distributions of juvenile lampreys recorded from the Boyne, Kells Blackwater, Deel and Kilwarden Rivers are given in Figure 5. Figure 6 shows the length percentage frequency distributions of juvenile lampreys recorded from the Longwood Blackwater, Mattock, Stonyford, Tremblestown and Yellow Rivers.

Figure 7 presents the length weight relationship of 200 lampreys collected from the Boyne catchment during the 12-14th September 2005. This chart indicates that weight increases exponentially with length in lampreys in the Boyne catchment. Exponential weight increase with length increase is an expected response for lampreys in order to store energy needed for transformation and migrations. It is clear therefore that feeding conditions on the Boyne are optimal for juvenile lampreys.

Mean density of juvenile lampreys recorded was 5.12 ± 2.35 lampreys m^{-2}. The mean densities of larvae from each river channel surveyed are given in Table 3. Summary statistics for density (number m^{-2}) for each river channel surveyed are provided in Table 4. Table 5 provides as assessment of the favourable conservation status of lampreys in the Boyne catchment

The highest densities of larvae were recorded on the Lower Boyne at Slane Bridge (79 larvae m^{-2}), Glen House (59 larvae m^{-2}), Obelisk Bridge (27 larvae m^{-2}), and Newgrange (25 larvae m^{-2}), on the Mattock River at New Bridge (38 larvae m^{-2}), and on the Kells Blackwater at Maudlin (22 larvae m^{-2}). Relatively high densities of larvae were also recorded on the River Deel near Riverstown Bridge (15.26 larvae m^{-2}) and on the lower Longwood Blackwater (15 larvae m^{-2}).

The distribution and characteristics of lamprey populations on the individual river channels is outlined below.

4.3.1 Boyne Main Channel

A total of twenty-seven sites were investigated on the main channel of the River Boyne from the freshwater tidal area at Obelisk Bridge up to near its source at Edenderry. The results from these sites are discussed under the following heading.

4.3.1.1 Lower Boyne –Drogheda to Navan

A total of eight sites were investigated in the stretch of river between Drogheda and Navan (Sites B1-B7, Q1). A total of 21m^2 of habitat was fished at the semi-quantitative (SQ) sites along this stretch resulting in the capture of 406 lampreys (376 g). Lamprey density at the SQ sites ranged from 5.67 m^{-2} at Broadboyne Bridge to 79.00 m^{-2} at Slane Bridge. This is the only section of the river which was not subjected to arterial drainage works. Several obstructions are present along this stretch including the weirs at Roughgrange, Rossnaree, Newgrange, Broadboyne, Slane, and Athlumley. During the current survey this stretch of river had excessive amounts of live and decaying filamentous algae. Water quality conditions were particularly degraded at Slane, Roughgrange, and Broadboyne which were considered to be in an advanced state of eutrophication. Large areas of the river were also overgrown with aquatic macrophytes, particularly *Schloenoplectus lacustris*. Supersaturated levels of dissolved oxygen (110 to 155 %) were recorded at a number of sites along this section during July.

Site B1 was located a short distance downstream of Obelisk Bridge on the left hand bank. The Boyne in this area is a large deep freshwater tidal river. This is an important angling area and adult sea trout were visible at the site. The surveyed area had a mean depth of 30 cm and had a substrate predominated by sand and silt. Rooted vegetation covered about 20% of the area surveyed and the dominant plant species present was *Sparganium erectum*. The estuarine plant *Enteromorpha* sp. was also

present. Lampreys were recorded in high numbers at this site (27.00 per m^2). Other fish captured were juvenile flounder, minnow, three-spined sticklebacks, and juvenile eels. Site B2 was located at Curly Hole - behind the car park on the N51. A number of adult sea trout were observed feeding in the shallows at this site. The area fished was a shaded backwater with a silt dominated substrate. This area is also affected by tidal movements. Reasonable numbers of lampreys were present at this site (8.67 per m^2) as well. Eels and sticklebacks were also recorded. Site B3 was located downstream of the old salmon weir near the Newgrange Interpretive Centre. The area fished was along a reed bed of *Phragmites australis* and *S. erectum*. Substrate was composed of silt and sand with some cobbles and rock also present. A total of 50 lampreys were captured in the 2 m^2 fished. Minnows, stoneloach, sticklebacks and eels were also recorded. Site B4 was located at Rossnaree in the grounds of Glen House. The site was located downstream of the weir at the confluence of the old canal and was dominated by silt substrate and also had an excessive coating of filamentous algae and detritus. A total of 105 juvenile lampreys were recorded in the 2 m^2 fished. Site B5 was located immediately downstream of Slane Bridge and Slane Weir. The area fished was a backwater alcove, a habitat which is considered to be ideal for lampreys. Lampreys at this site were living in a fine sandy substrate. There was an excessive amount of organic debris at this site which was presumably providing food for the larvae. The recorded density of 79.00 m^{-2} was the highest for the current survey. Other fish species recorded at this site were gudgeon, sticklebacks, minnows and eels. Site B6 was located approximately 200 m upstream of Broadboyne Bridge. This was a difficult and inaccessible site with mean water depths of 60 cm. Electrofishing efficiency at this site was considered to be low and this may explain the relatively low densities recorded here. Site B7 was located approximately 300 m downstream of Athlumley Weir. The river here is approximately 20 m wide and has cut stone walls along one bank. The area investigated was at a backwater habitat located at a bend in the river. A total of 9 m^2 were fished resulting in a catch of 105 lampreys (11.67 m^{-2}). Stone loach, minnow and a single small brown trout were also recorded here.

Assessment: It is likely that populations of both *Lampetra planeri* and *Lampetra fluvialitis* are present along this section of the river. Sea lampreys were not detected during the current survey but may also be present. Lamprey populations and their habitats here are considered to be well above favourable conservation status. The fact that this area of the river was not subjected to drainage works in the 1980s has ensured a wide availability of nursery habitats. However, populations are currently threatened by pollution problems which appear to be worsening. Re-development of the Boyne canal and other river works could also impact on lampreys. The presence of several large weirs along the river may restrict the migration of both species along this stretch.

4.3.1.2 Lower Middle Reaches: Navan to Trim

A total of seven sites were investigated along the stretch of river between Navan and Trim (Sites B8-B13). This stretch of river was affected by the 1980's arterial drainage scheme and has mainly been left with high banks and reduced instream physical diversity. All of the weirs were removed along this stretch and it is now a relatively open channel dominated by glide habitat. Some post drainage rehabilitation work has been undertaken but this has focused exclusively on improving habitats for salmonids. This area of river appeared to be somewhat cleaner than the areas of river below Navan at the time of the survey with much reduced growths of filamentous algae. However, this channel was also overgrown with macrophytes at the time of the survey. A total of 48m^2 of habitat was fished at the sites along this stretch resulting in the capture of 165 lampreys (191 g). Lamprey density at the sites investigated ranged from 0.63 m^{-2} at Bective Bridge to 11.40 m^{-2} at Trim Castle.

Plate 25 Excessive growths of filamentous algae and associated calcification on the River Boyne downstream of Broadboyne Weir.

Site B8 was located downstream of Kilcarn Bridge, approximately 2.5 km upstream of the Kells Blackwater confluence and within the suburban sprawl of Navan. The river here is up to 30 m wide and has a substrate dominated by cobble/rubble. The area surveyed was on a side channel to the left of the island downstream of the Bridge. The substrate in this area was dominated by fine sand and had a covering of filamentous algae. A total of 10m^2 were fished resulting in the capture of 45 lampreys (4.50 per m^2). Juvenile salmon, trout, and sticklebacks were also recorded. Site B9 was located at Ballinter Bridge, approximately 600 m upstream from the Skane confluence. The river was visibly clean in this area with a much reduced growth of filamentous algae. The surveyed area was however deeper with a mean depth of 60m. The substrate in the surveyed area was dominated by silt and had a flow of approximately 5 cm sec^{-1}. A total of 13 lampreys were captured (1.86 per m^2). No other fish were recorded. Site B10 was located at Bective Bridge. The area surveyed included sections located immediately upstream and downstream of the bridge. Substrate in the surveyed area was composed of silt and sand. Plants recorded in the surveyed section consisted of *S. erectum*, *Apium nodiflorum*, and *Potamegeton* sp. A total area of 10 m^2 was fished resulting in the capture of 16 lampreys (1.60 per m^2). Minnow and stoneloach were recorded at this site. Crayfish were also present. Sites B11-13 were all located in the vicinity of Trim town. The Boyne at Trim is still a large river – up to 25 m wide. The river is dominated by glide habitat and has excessive growth of macrophytes. Substrate is dominated by rock and cobble. In the three sites, a total of 21m^2 was investigated resulting in the capture of 91 lampreys. Density of lampreys recorded ranged from 3.63 to 11.40 lampreys m^{-2} at the three sites. Crayfish were recorded at these three sites.

Assessment: It is possible that populations of both *Lampetra planeri* and *Lampetra fluvialitis* are present along this section of the river. The status of lamprey populations in the optimal habitats assessed was rated as unfavourable. However, lampreys were present at reasonable numbers at all sites and several age groups were present. Therefore the overall status is considered to be favourable. Lampreys are less abundant along this stretch of river compared to the lower Boyne. This may be a result of the

drainage history of the river which resulted in the removal of the alcove habitats which lampreys prefer. Lampreys and their habitats in this area are under threat from pollution and drainage maintenance.

4.3.1.3 Upper Middle Reaches: Trim to the Deel Confluence

A total of four sites were investigated on the main stem of the River Boyne between Trim and the confluence of the River Deel (B14-B18). This stretch of river has been drained and channelised and spoil heaps from the drainage scheme – dumped on the banks in the 1980's – are still present in some areas. A total of 48m^2 of habitat was fished at the sites along this stretch resulting in the capture of 165 lampreys (191 g). Lamprey density at the sites investigated ranged from 0.11 m^{-2} at Derryinydaly Bridge to 2.40 m^{-2} near Inchantore Bridge. Site B14 was located immediately above the confluence of the Tremblestown River. This is a large entrenched drained river with a width of approximately 25m. The channel was partially clogged with aquatic macrophyte growth, including *Sparganium. flutans*, *S. erectum*, *S. lacustris*, *Nuphur lutea*, *Potomegeton* sp., *A. nodiflorum,* however, water quality appeared to be good and no filamentous algae were present. The surveyed area had a mean depth of 30 cm and had a very soft marl substrate. A total of 5 m^2 were fished resulting in the capture of 8 ammocoetes. Site B15 was located immediately upstream of Derryinydaly Bridge. The area surveyed had a mean depth of 20 cm and had a predominantly silt substrate. A total of 9 m^2 were fished but only a single lamprey ammocoete was recorded. The low density of lampreys at this site may reflect a recent disturbance of the site or perhaps the discontinuous distribution of lampreys. Habitat at this site was physically suitable and large numbers of larvae of the burrowing mayfly *Ephemera danica* were present. This larvae often occurs in the same habitats as lampreys.

Site B16 was located at Scarriff Bridge. The Boyne is a big river in this area and is channelised and deepened. Scarriff Bridge is known to salmon anglers on the river Boyne as being the upper limit of where one would reasonably expect to catch a salmon after a summer flood. A total of 12 m^2 were fished at a cattle drinking area at this site resulting in the capture of two lampreys. Common plants in the area fished were *A. nodiflorum*, *Rorippa nasturtium-aquaticum*, and *S. erectum*. Minnow and small numbers of juvenile trout, salmon, parr, stoneloach, and eels were attracted to the electrode while fishing. Site B17 was located 300 m upstream of Scariff Bridge. Flow rates on the main channel were faster in this area and bedrock was exposed on the bed of the river in some areas. Banks were over 3m high and the wetted width was 10m. One lamprey was captured during the investigation of 3m^2 of sandy substrate. No other suitable habitat was present in the area. Site B18 was located at Inchantore Bridge, approximately 200 m upstream of the confluence with the Longwood Blackwater. This is heavily channelised stretch which has little natural character. Moreover, farm animals are given unrestricted access to the river resulting in severe bank erosion in places. The area fished was a small backwater formed behind where a dead tree had lodged. Access and fishing conditions were difficult and the efficiency of the survey was considered to low. A total of 5 m^2 were fished resulting in the capture of 12 lampreys (2.40 per m^2).

Assessment: It is likely that only one species, *Lampetra planeri,* occurs along this section of the river. Therefore the overall status is considered to be favourable. Lampreys and their habitats in this area are under threat from pollution and drainage maintenance.

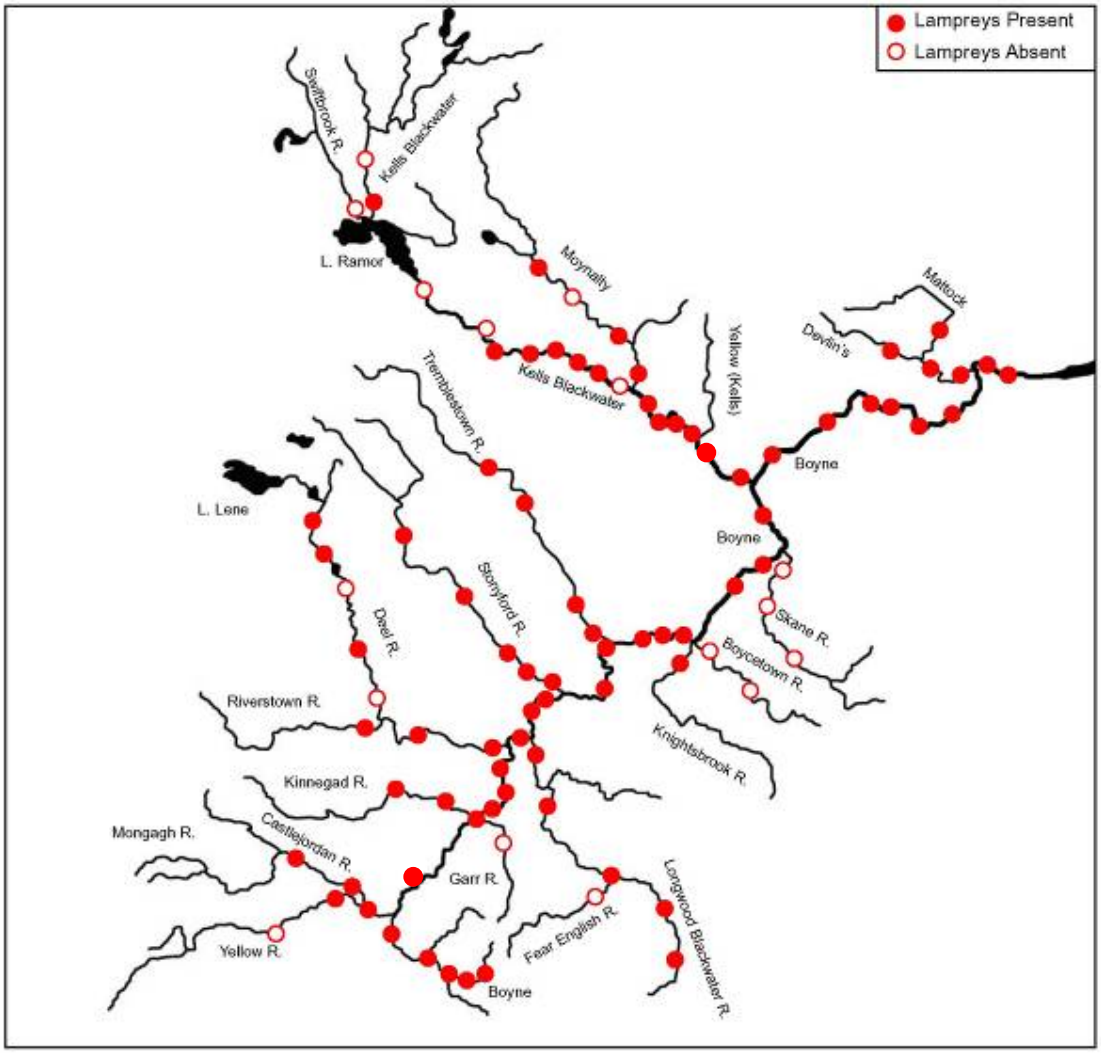


Figure 4 Map of the Boyne catchment illustrating the distribution of juvenile lampreys at the 91 sites investigated during the 2005 survey.

4.3.1.4 Upper Reaches

A total of nine sites were investigated on the upper River Boyne from Stoneyford Bridge to near its source at Edenderry (B19-B27). From this point upstream the Boyne starts to look less like a river and more like a drainage channel. The river has become clogged with vegetation and is overgrown by bankside vegetation in parts. A total of 88m² of habitat was fished at the sites along this stretch resulting in the capture of 98 lampreys (94.5 g). Lamprey density at the sites investigated ranged from 0.13 m^{-2} at a site near Edenderry to 4.60 m^{-2} near Stoneyford Bridge. The average lamprey density in the upper Boyne was 1.11 per m².

Assessment: It is likely that the only lamprey species present in this stretch of river is *Lampetra planeri*. Lamprey populations here are considered to be probably just at favourable conservation status.

4.3.2 Mattock and Devlin's Rivers

The Mattock is a small sub-catchment which joins the Boyne in the freshwater tidal area upstream of Curly Hole. It has one main tributary, the Devlin's River. Three sites were investigated on the Mattock River (M1-M3) while one site was investigated on the Devlin's River at Devlin Bridge (M4). A total of 18 m² was fished at the four sites resulting in the capture of 234 lampreys. The mean lamprey

density for sites on this river system was 13 lampreys per m^{-2}. The highest lamprey density recorded (38.00 lamprey m^{-2}) was at New Bridge on the lower Mattock. This site was located in a freshwater tidal area immediately upstream from the bridge. The substrate was composed of sand and silt and was partially shaded. There was an accumulation of organic debris in the surveyed area and the habitat was considered to be ideal for juvenile lampreys. Minnows and flounder were also recorded at this site. A density of 13.80 lamprey m^{-2} was recorded at the site on the Devlin's River. This site was located on an alcove habitat immediately upstream of Devlin's Bridge. Substrate was dominated by fine silt and an accumulation of organic debris was present.

Assessment: It is likely that populations of both *Lampetra planeri* and *Lampetra fluvialitis* are present in this sub-catchment. Lamprey populations and their habitats here are considered to be above satisfactory conservation status. Populations are currently threatened by pollution.

4.3.3 Kells Blackwater Sub-Catchment

4.3.3.1 Kells Blackwater Main Stem Downstream of Lough Ramor

The Kells Blackwater is the largest tributary of the Boyne and a total of 21 sites were investigated on this river (Kb1-15) and its tributaries; the Moynalty (Moy1-4) and the Swiftbrook (Sw). A quantitative site (Q2) was also undertaken in this catchment. A total of 161 m^2 were investigated resulting in the capture of 267 lampreys. Lampreys were present at 15 (71%) of the sites investigated. The overall mean density of lampreys ranged in the catchment was 1.65 per m^2. The Kells Blackwater was also drained during the 1980's, however an extensive stretch of the middle reaches of the river was unaffected by this scheme. The mean density of lampreys found in the undrained section of the river (i.e. from below Maudlin Bridge to Claven's Bridge) was 5.2 per m^2. The Kells Blackwater also suffers from pollution possibly originating largely from the eutrophic Lough Ramor and the urban areas of Kells and Navan.

Site Kb1 was located near the confluence of the Kells Blackwater and the Boyne. The river is approximately 20 m wide in this area and was showing signs of serious pollution at the time of the survey. The site was located immediately upstream of the old Mill weir where large deposits of silt had accumulated. A total of 7 m^2 were fished resulting in the capture of 17 lampreys (27.8g). A single brown trout was also captured during the assessment. Plant species present at the surveyed area included *G. maxima*, *S. erectum,* and *Phalaris arundinacea*. Dissolved oxygen at the site on the day of sampling was 97% saturation (9.4 mg l^{-1}) while conductivity was 548 μs cm^{-1}. The bed of the river was heavily silted and excessive growth of filamentous algae was present.

The lower 3 km of the Kells Blackwater (from site Kb1 to site Kb2 at Tatestown) was walked on the 24th July 2005 to assess lamprey habitats in this area. The Kells Blackwater is a large sluggish River in this area which is generally semi-natural in character and apparently undrained. Cascades are present on the river downstream of Liscarton. This stretch of the river has a reputation of being a spring salmon holding area. Potential lamprey habitats were noted along the entire section including lateral silt beds and a few backwater habitats - particularly at the back of the island upstream of Rathaldron Castle. However, it was also noted that the river was visibly polluted. Much of this pollution appeared to be originating from an outflow at the Liscarton water works.

Site Kb2 was located at Tatestown, approximately 4 km upstream from the Boyne confluence. The area fished included a microhabitat formed by the roots of a willow tree. A total of 6 m^2 of habitat were investigated and 23 lampreys were intercepted (density 3.83 per m^2). Minnow and sticklebacks were also recorded. Site Kb3 was located immediately upstream of Donapatrick Bridge. The channel here is heavily confined within a trapezoidal shaped channel – a legacy of the 1980s drainage scheme. The channel is overgrown with macrophytes (*S. lacustris, S. erectum, G. maxima, N. lutea*). Filamentous algae were also present at the site indicating nutrient enrichment. A total of 22 lampreys were captured in

the 12 m^2 area fished. Site Kb4 was located at Martry and was accessed overland. This is also a drained area of the Kells Blackwater and has a mean width of 10 m and a mean bank height of 3 m. This was a difficult site to fish and efficiencies were low. A total of two lampreys were recorded in the 7 m area fished. Site Kb5 was located immediately upstream of Bloomsbury Bridge. A total of 21 lampreys were recorded in the 12 m^2 fished. Crayfish, stoneloach and minnows were recorded at this site. Site Q2 was located immediately below Bloomsbury Bridge. A total of 37 lampreys were recorded in the 4 m^2 fished at this site.

Site Kb6 was located immediately downstream of the weir near the Headford Road Bridge near Kells. Habitat was sub-optimal at this site and no lampreys were recorded in the 10m^2 assessed. The substrate here consisted of stones with some silt. Juvenile pike, roach, eels, gudgeon, minnow, stickleback and eels were recorded here. Roach have been present in the Boyne catchment since the early 1980's (Fitzmaurice, 1981). Site Kb7 was located approximately 200 m downstream of Maudlins Bridge (the N52). The stretch of river is undrained and retains a high degree of naturalness. A lamprey density of 22 per m^2 was recorded here, the highest on the Kells Blackwater. Lamprey habitats in this area of the river are present in a variety of lateral backwaters and behind islands. Minnows and sticklebacks were recorded during the fishing. Significant numbers of juvenile salmonids were observed in adjacent habitats. Site Kb8 was located at Maudlin's Bridge. Silt beds which had built up behind the piers of the bridge were sampled. A total catch of 25 lampreys was made in the two 1 m^2 areas surveyed. Site Kb9 was located upstream of Mabe's Bridge in the middle of the undrained stretch of the river. A total of 5 m^2 were fished resulting in a catch of 48 lampreys (9.60 per m^2). Extensive lamprey nursery and spawning habitats are present in this area of the river. Floating river vegetation was also present here. Site Kb10 was located at Claven's Bridge at the upper end of the extensive undrained section. A small weir was present upstream of the bridge and this may represent an obstacle to migrating lamprey. Water is abstracted here for use in an industrial unit. Site Kb11 was located at Carnacross Bridge. This section has been drained but it has recovered well and lamprey habitats are present. The influence of Lough Ramor's poor water quality on the river was starting to be noticeable at this site with the reappearance of filamentous algae and elevated turbidity. A total of 7 m^2 were investigated resulting in the capture of 13 lampreys (1.86 per m^2). Lampreys were present behind beds of *S. erectum*. Gudgeon, sticklebacks and crayfish were noted at this site. Site Kb12 was located at Daly's Bridge - the second bridge downstream of Lough Ramor. The lake influence was obvious at this site with elevated turbidity and *Anadonta* sp. shells were recorded. Canadian pondweed *Elodea canadensis* was also common at this site. Sticklebacks and roach were captured during the electrical fishing assessment, but lampreys were absent. Potential lamprey habitat in this arterially drained stretch of river was sparse and where it occurred was sub-optimal at best. Site Kb13 was located 200 m downstream of the outflow from Lough Ramor. Water quality was visibly poor at this site and no lampreys were recorded. Minnow and eels were present and *Anadonta* sp. shells were also recorded at this site.

Assessment: It is possible that populations of both *Lampetra planeri* and *Lampetra fluvialitis* are present along this section of the river. However, it is likely that *Lampetra planeri* is the main, if not only, species present. Overall, lamprey populations and their habitats here are considered to be at favourable conservation status on the Kells Blackwater. However, lamprey densities were significantly lower on drained and polluted sections where lamprey and habitats populations are below favourable conservation status. Lamprey populations in the Kells Blackwater are currently threatened by ongoing pollution problems and drainage maintenance.

4.3.3.2 Kells Blackwater Catchment Upstream of Lough Ramor

Site Kb14 was located at Murmod Bridge upstream of Lough Ramor and near Virginia, Co Cavan. Repairs were being undertaken to Murmod Bridge at the time of the survey and a temporary culvert constructed from soil and concrete pipes was being used to cross the river. A total of 5 m^2 of undisturbed habitat was investigated and two lampreys were captured. Stoneloach, stickleback, roach,

minnow and trout were also recorded. Site Kb15 was located upstream of Stranaquerty Bridge. The river has a wetted width of 10 m in this area and a mean depth of 25 cm. Crayfish, minnow, stone loach, gudgeon, trout, eels and pike were recorded in the total of 8m² surveyed. No lampreys were recorded. The substrates surveyed were comprised mainly of gravel with some silt present and so were sub-optimal. In fact, no optimal habitats could be found in this stretch of the upper Kells Blackwater. Site Sw was located on the lower Swiftbrook River, which flows into Lough Ramor. The site surveyed was visibly polluted with sewage at the time of the survey. No lampreys were recorded despite some suitable lamprey habitats being present. Three-spined sticklebacks were recorded at this site.

Assessment: Brook lampreys are present at an unsatisfactory conservation status on the Kells Blackwater system above Lough Ramor. Lamprey populations here are currently threatened by pollution and drainage maintenance.

4.3.3.3 The Moynalty River

Four sites comprising a total of 30 m² were investigated on the Moynalty River. A total of 8 lampreys were recorded. Site Moy1 was located immediately upstream of Fyanstown Bridge. This section of the river has been deepened by rock cutting / blasting and was visibly polluted. However some silty areas were present and 5 lampreys were captured in a total of 5 m² of habitat. Site Moy2 was located in farmland upstream of Fyanstown Bridge. This stretch of river has a substrate of boulder clay and two lampreys were recorded in a survey of 7m² at a cattle drinking area. Site 3 was located in the pond downstream of Mahonstown Bridge. No lampreys were recorded during an investigation of 10 m² of the lateral areas of the pond. The pond here is impounded by a small weir which is likely to be impassable to lampreys. Site Moy4 was located in another mill pond upstream of the weir at Moynalty Village. This weir is also likely to be a migration barrier to lampreys. One lamprey (4.8 cm) was recorded in an 8m² area fished.

Assessment: One species of lamprey is present on the Moynalty River, probably *Lampetra planeri*. Lampreys are present at an unsatisfactory conservation status level. Lamprey populations here are currently threatened by pollution and drainage maintenance.

4.3.4 Skane, Boycetown, and Knightsbrook Rivers

These three minor tributaries join the Boyne in the stretch between Navan and Trim. Three sites were investigated on the Skane catchment. Site Sk1 was located upstream of Powdstown Bridge. This stream was 3.5m wide and had a mean depth of 40cm. At the time of the survey the site was visibly polluted and was heavily silted. No lampreys were captured; however, salmon, trout, minnow and stickleback were recorded. Site Sk2 was located downstream of the next bridge upstream. This site was seriously polluted and had excessive filamentous algae growth, siltation, and calcification. Supersaturated dissolved oxygen levels were recorded: 143 %. No lampreys were recorded at this site. Trout and sticklebacks were present. The Dunshaughlin to Trim sewage pipeline was under construction in this area. This pipeline will carry sewage away from the Skane River in the future. Site Sk3 was located at Kilmessan Bridge and an area of 10m² of physically ideal habitat was surveyed. No lampreys were recorded however.

Two sites were surveyed on the Boycetown River. No lampreys were recorded despite the presence of physically suitable habitat. Site one was located near Boycetown Bridge while site two was located at Miltown Bridge. This river has a wetted width of 2-3 m and appears to have poor water quality. Salmon, trout and sticklebacks were present at both sites investigated. Site Kn1 was located on the Knightsbrook River beside the Trim water treatment plant. This river had a wetted width of 4 m and a mean depth of 30 cm at this site. Bankside vegetation was dominated by *Epilobium hirstum* and floating river vegetation was present in this fast flowing stream. Salmon, eel, trout, stoneloach and

sticklebacks were present. Lampreys were present at a low density; however, there is a paucity of lamprey nursery habitat along this stream.

Assessment: Lampreys are apparently absent from the Skane and Boycetown Rivers. This is thought to be due to pollution and a restricted abundance of suitable habitats. *Lampetra* sp(p), probably only *Lampetra planeri,* was present on the Knightsbrook River. Lampreys are present at an unsatisfactory conservation status level in these tributaries of the middle reaches of the Boyne.

4.3.5 Tremblestown and Stonyford Rivers

A total of four sites were surveyed on the Tremblestown (or Athboy) River (TM1-4). A total of 26 m^2 were surveyed resulting in the capture of 64 lampreys. Site Tm1 was located near the Boyne confluence at Kilnagross Bridge. Some post-drainage rehabilitation works have apparently been undertaken on this stretch. This has created a diversity of habitats within the trapezoidal shaped channel. Dominant aquatic plants at this site were *A. nodiflorum*, *S. flutans* and *S. erectum*. Lampreys were present at low densities in suitable microhabitats. Stoneloach and minnows were also recorded. Site Tm2 was located near the next bridge upstream from the Kilnagross Bridge. This stretch of river was more sluggish and was very difficult to access due to high and overgrown banks. Lampreys were also present here in low densities. Site Tm3 was located in farmland downstream of the village of Athboy. The river in this area has a mean wetted width of 6.5 m and a mean depth of 35 cm. The site was fished after a shower of rain and the river became very coloured as a result of untreated storm sewer discharged from Athboy. A total of 10 m^2 of suitable habitat was fished resulting in the capture of 26 lampreys. This site had filamentous algae present and the instream flora species recorded included *S. flutans*, *S. erectum*, *A. nodiflorum* and *Potomogeton* sp. Site Tm4 was located upstream of Athboy village and small numbers of juvenile lampreys were recorded. This site was very heavily silted. Trout and sticklebacks were also recorded.

A total of five sites were located on the Stonyford River which joins the Boyne eight kilometers west of Trim. This is a heavily drained and channelised river which is visibly polluted in its lower reaches. Some instream physical rehabilitation work has been carried out. However this has been targeted at salmonids only. Overall a total of 40 m^2 were fished and mean lamprey density of 1.51 per m^2 was recorded. Site S1 was located at Stonyford Bridge. A total of 10 m^2 of habitat was fished and 12 lampreys were captured. Ten of the lampreys captured were caught in a single 0.5 m^2 behind a large rock. A coating of filamentous algae was present at this site. A few salmon parr were also recorded at this site. Site S2 was located approximately 200 m upstream of Shanco Bridge. Nominal numbers of lampreys were recorded here on suboptimal habitats. Site S3 was located in an alcove habitat immediately upstream of Earl's Bridge. The river here is 6 m wide and has a mean depth of 35 cm. Substrate consists of gravel and cobble. This area of the river is heavily channelised and very little suitable lamprey nursery habitat occurs. A total of 17 ammocoetes were recorded in the 5 m^2 of habitat fished. Aquatic plants present at the site included *Apium* and *Rorripa* and a coating of filamentous algae was present. Site S4 was located upstream of Cloonbrook Bridge. Lampreys were present in low numbers at the restricted available microhabitats. Site S5 was located at the ford downstream of the N51 Bridge east of Devlin. This site was contaminated by sewage and both sewage fungus and filamentous algae were recorded at the site. Two ammocoetes were recorded in the 12 m^2 of habitat investigated. Stoneloach, minnow, trout and eels were also recorded.

Assessment: An overall density of 1.85 lampreys per m^2 was recorded on these two rivers and recorded densities at two areas of optimal habitats assessed were low. A number of age groups of lampreys were present and they were well distributed in the catchment. It is likely that only one species of lamprey occurs in the Tremblestown and Stonyford catchments - *Lampetra planeri*. A tentative evaluation of unfavourable conservation status is made. Lamprey populations in both catchments are currently threatened by pollution and drainage maintenance.

4.3.6 Deel Sub-Catchment

A total of eight sites were investigated in the Deel sub-catchment. Lampreys were present at five out of the eight sites investigated and the mean density of lampreys recorded was 2.9 per m^2. Site D1 included sections upstream and downstream of the Bridge at Ballyadams. This site was heavily silted and visibly polluted. No lampreys were recorded. Sites D2-D5 were located near Inan Bridge, Raharney, Cummer Bridge and Ballynacor Bridge (N52) respectively. The River Deel is heavily channelised throughout the length of this section and has banks ranging from 1.5m to 6m in height. Filamentous algae are present on the bed of the river throughout this area. There is a paucity of lamprey nursery habitats and the numbers recorded were low. The site near Cummer Bridge was located approximately 150 m downstream of the bridge and a total of 55 lampreys were recorded in an area of 10 m^2. Most of these were captured at the base of an undercut bank in an area of approximately 2 m^2 of silt with good cover of *Rorripa*. The river channel upstream of Ballynacor Bridge had been recently maintained, however, lampreys were present in low numbers in the silt deposits under the bridge. Sites D6, D7 and D8 were located near Mooretown Bridge, Drumcree and Riverstown Bridge respectively. No lampreys were recorded at the site fished downstream of Moorsetown Bridge. Site D7 was located upstream of a small lake and nominal lampreys were recorded in patches of habitat along a 100 m stretch. Salmon, minnow, sticklebacks and trout were also recorded at this site. A site upstream of here was also viewed; however the river had been recently dredged so was not fished.

Assessment: River/brook lamprey, probably *Lampetra planeri,* was confirmed from the Deel catchment. Lampreys are present at an unsatisfactory conservation status level. As in other tributaries of the Boyne, lamprey populations here are currently threatened by pollution and drainage maintenance.

4.3.7 Longwood Blackwater Sub-Catchment

A total of five sites were investigated on the Longwood Blackwater including its tributary - the Fear English. A total area of 30 m^2 was fished and the mean density of lampreys recorded was 4.62 per m^2 (0.20-15.00 per m^2). Site Lb1 was located upstream of Longwood sewage works. This area of the river had a mean width of 5 m and is heavily channelised. An area of 5m^2 was surveyed in an alcove habitat resulting in the capture of 75 juvenile lampreys (15 per m^2). The substrate of the area surveyed was dominated by silt and had a back flowing current. Minnow, sticklebacks and trout were also recorded. Site Lb2 was located in Enfield. This area of the river is heavily drained / channelised. However, despite this the channel has recovered well and has scoured a new sub-channel with islands and backwaters. This is ideal habitat for trout and a good number of suitable lamprey microhabitats are also present. The channel was also remarkably clean. Lampreys were present at a density of 3.1 per m^2.

Site Lb3 was located at Bishop's Chair Bridge. This channel was overgrown with *S. flutans, S. erectum* and *Berula erecta* and had little instream diversity. Water flows at this site may have been too weak to scour the channel as in site Lb1 and little post-drainage physical recovery has occurred here in the 20 years since the drainage scheme was completed. Low numbers of lampreys were nonetheless present. A similar situation has occurred at site Lb4. This area of the river is drain-like in character. One lamprey was recorded here in the 5m^2 fished. No lampreys were recorded on the Fear English stream, which was visibly polluted at the time of the survey.

Assessment: It is likely that only one species of lamprey occurs in the Longwood Blackwater catchment - *Lampetra planeri*. Lampreys are present at an unsatisfactory conservation status level. As in other tributaries of the Boyne, lamprey populations here are currently threatened by pollution and drainage maintenance.

4.3.8 Kilwarde, Kinnegad and Garr Rivers

Two sites were fished on the Kilwarden/Kinnegad River. This is a highly degraded watercourse which has suffered from drainage and pollution in the past. Site K1 was located downstream of Clonard Bridge. This area of the river is very sluggish and has a wetted width of 5m and a mean depth of 40 cm. A total of 20 ammocoetes were recorded in an area of 10 m^2. Site K2 was located immediately upstream of the Kinnegad sewage works and was visibly polluted. A density of 4 lampreys per m^2 was recorded here. The mean depth of the river here was >1m so fishing was very difficult. The substrate here is dominated by silt/mud and this is being used as a nursery area by lampreys. It is not clear where lampreys would spawn in this river however. No lampreys were recorded at the site investigated on the Garr River.

Assessment: One species of lamprey was confirmed from the Kilwarden catchment, namely *Lampetra planeri*. Lampreys are present at an overall favourable conservation status level. Lamprey populations here are currently threatened by pollution and drainage maintenance.

4.3.9 Castlejordan / Yellow Sub-Catchment

A total of five sites were investigated in the Yellow River catchment. Three sites were located on the Yellow River itself, one site was located on the Castlejordan River and one site was located on the Monga River. Overall a total of 32 m^2 was investigated resulting in the capture of 96 juvenile lampreys. The main area for lamprey production in this sub-catchment is the Yellow River. This river has been heavily channelised but water quality is apparently satisfactory. This is a spring fed river and had a good flow even during the study period when most rivers were low. Site Y1 was located upstream of Clongall Bridge. Good numbers of lampreys were living between the roots of a stand of *S. erectum* and a total of 65 lampreys were recorded in the 10 m^2 surveyed – despite the fact that fishing conditions were very difficult here as the channel was deep and visibility between the reeds was low. Minnow, stoneloach and brown trout were also recorded. Site Y2 was located at a cattle drinking area downstream of Sheep Bridge. This area of the Yellow River is in poor physical condition and little post-drainage recovery has occurred here. Good numbers of lampreys were recorded in the cattle drinking area. Site Y3 was located at Garr Bridge. Boulder clay is exposed here and the channel is overgrown with *S. erectum* and other aquatic macrophytes. One lamprey was recorded in the 5 m^2 area fished. Site Y4 was located on the lower reaches of the Castlejordan River. This stretch of river has been physically rehabilitated and would provide ideal spawning conditions for lampreys. There is a paucity of potential nursery habitat here however and only one lamprey was recorded in a total area of 5 m^2 fished. Site Y5 was located on the degraded River Monga. One lamprey was recorded here in the 5 m^2 fished at a cattle drinking area.

Assessment: River/brook lamprey (probably *Lampetra planeri*) were confirmed from this catchment. Lampreys are present at an overall favourable conservation status level.

Table 3 Mean density of juvenile lampreys recorded in each river assessed during the 2005 Boyne lamprey survey.

River	Tributary	Number of sites	Area fished (m^{-2})	Mean Density (No. m^{-2})	Min. Density (No. m^{-2})	Max. Density (No. m^{-2})
Boyne		29	198.5	9.05	0.11	79.00
Kells Blackwater		16	138.5	3.20	0.00	22.00
Deel		7	58	1.19	0.00	5.50
Longwood Blackwater		5	30	4.62	0.20	15.00
Stonyford		5	40	1.51	0.17	3.40
Mattock		4	18	16.61	4.50	38.00
Tremblestown		4	26	2.28	1.50	2.60
Kells Blackwater	Moynalty	4	30	0.35	0.00	1.00
Yellow		3	20	4.17	0.00	6.50
Skane		3	35	0.00	0.00	0.00
Yellow	Castlejordan/Monga	2	12	0.17	0.14	0.20
Boycetown		2	15	0.00	0.00	0.00
Deel	Riverstown	1	5.7	15.26	15.26	15.26
Kilwarden	Kinnegad	1	4	4.00	4.00	4.00
Knightsbrook		1	5	2.60	2.60	2.60
Kilwarden		1	10	2.00	2.00	2.00
Garr		1	20	0.00	0.00	0.00
Kells Blackwater	Swiftbrook	1	6	0.00	0.00	0.00
Longwood Blackwater	Fear English	1	7	0.00	0.00	0.00
Total		91	678.7			

Table 4 Summary statistics for length (cm) of juvenile lampreys for each river channel surveyed during the 2005 Boyne lamprey survey.

River	Tributary	N	Mean	Min	Max	St.Dev.	95% C.I.
Boyne		791	8.1	2.5	16.7	2.6	0.18
Kells Blackwater		220	9.7	0.5	17.2	3.4	0.46
Mattock		165	9.4	4.8	15.2	2.4	0.37
Longwood Blackwater		130	7.2	3.2	15.7	2.9	0.49
Yellow		95	8.7	1.8	14.3	2.6	0.53
Deel	Riverstown	87	7.8	1.6	12.5	2.7	0.56
Deel		76	9.5	5.4	15.7	2.2	0.50
Mattock	Devlins	69	10.6	7.8	14.8	1.6	0.37
Tremblestown		64	11.3	4.8	16.4	2.9	0.70
Stonyford		48	10.0	4.6	13.5	2.5	0.72
Kilwarden		20	10.5	6.3	13.8	2.4	1.04
Kilwarden	Kinnegad	16	10.8	6.8	13.7	2.0	0.99
Knightsbrook		13	10.7	5.3	14.5	3.6	1.94
Kells Blackwater	Moynalty	12	10.5	4.8	17.7	4.1	2.55
Yellow	Castlejordan	1	10.1	10.1	10.1		
Yellow	Castlejordan/Monga	1	10.7	10.7	10.7		

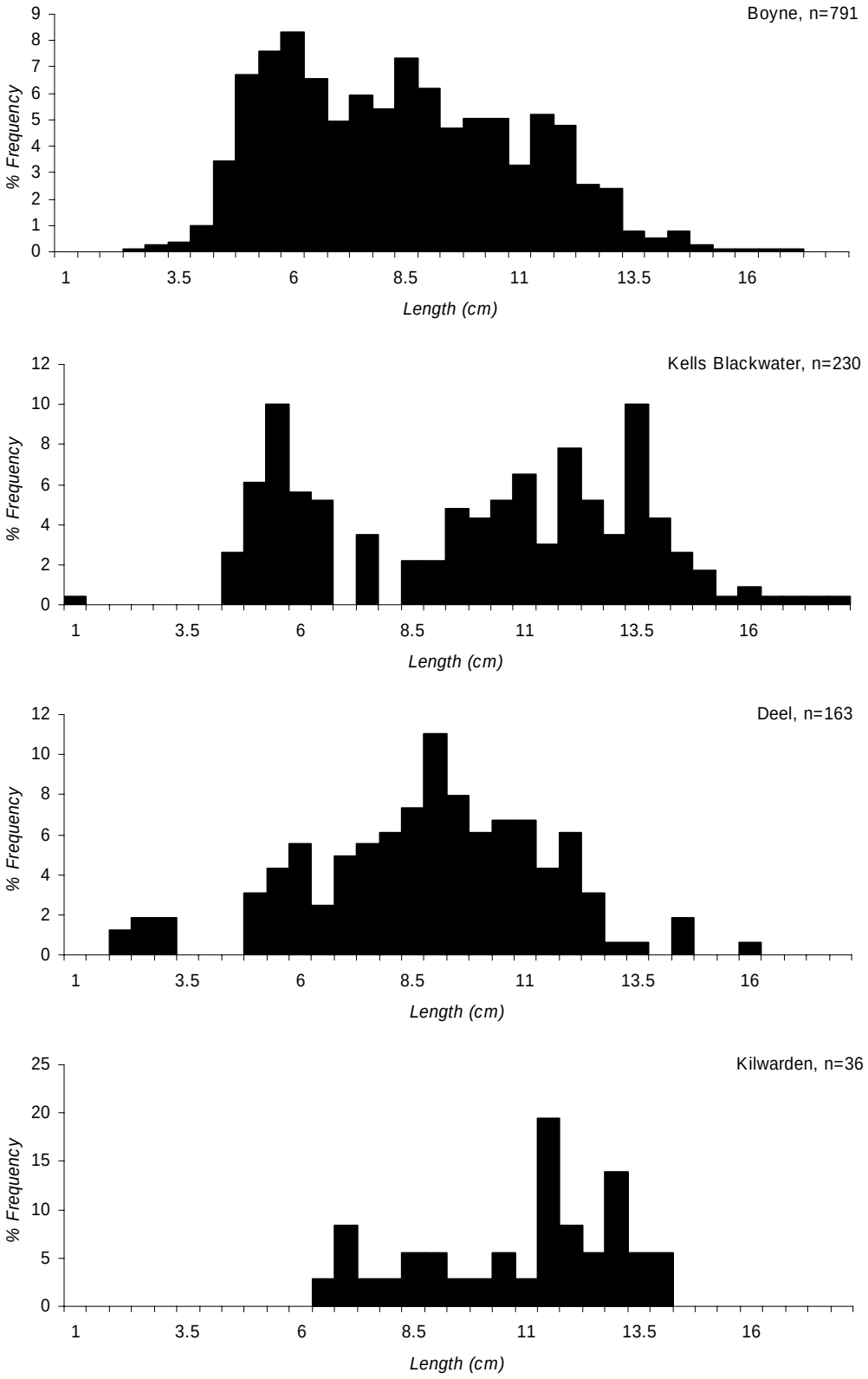


Figure 5 Length percentage frequency distributions of juvenile lampreys recorded from the Boyne, Kells Blackwater, Deel and Kilwarden Rivers during the 2005 survey.

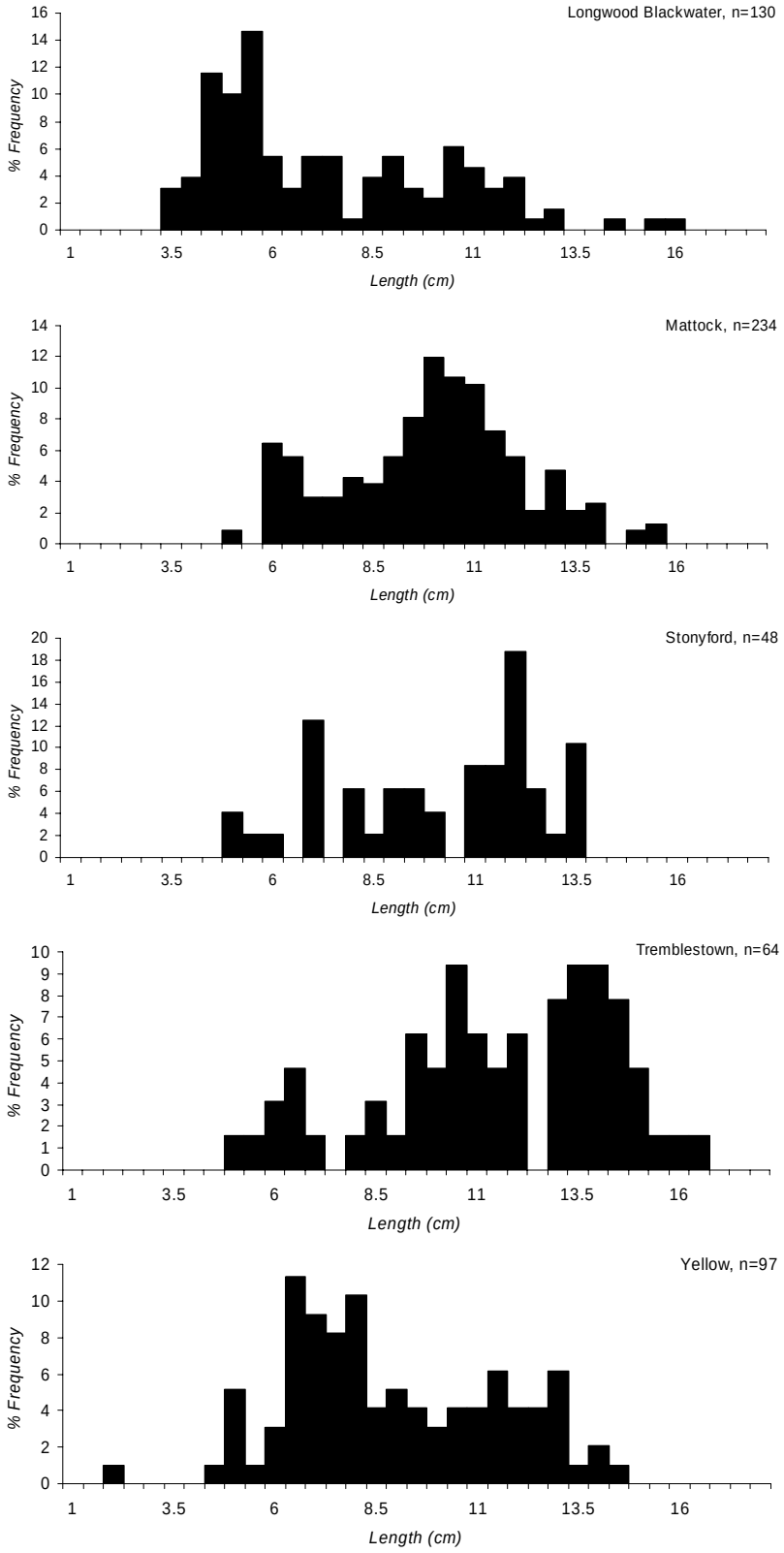


Figure 6 Length percentage frequency distributions of juvenile lampreys recorded from the Longwood Blackwater, Mattock, Stonyford, Tremblestown and Yellow Rivers during the 2005 survey.

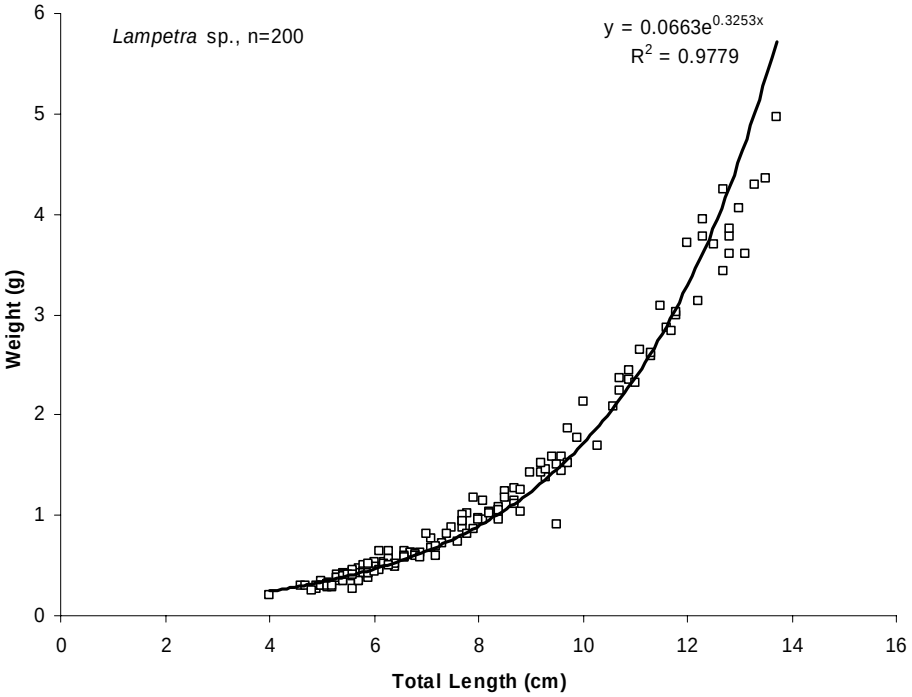


Figure 7 Length weight relationship of 200 lampreys collected from Boyne catchment during the 12-14th September 2005. All measurements were made on formalin preserved specimens under laboratory conditions.

4.4 Environmental Factors

The most suitable habitats for lampreys on the Boyne (and other rivers) are located in alcove or backwater habitats which have a mean depth of less than 40 cm and a moderately soft but stable silt substrate. The presence of some rooted vegetation cover, large woody debris, moderate shade and a sloped bank makes such habitats ideal as lamprey nurseries. Where these alcove habitats occur in a reach of river with good gradient and a well defined riffle/glide/pool sequence, excellent lamprey habitat is created. These areas must also be accessible to lampreys migrating upstream and have suitable spawning habitat nearby. Where all the above conditions occur, large numbers of lampreys can be expected.

In Table 6, summary statistics for lamprey catch at sites considered to have (a) optimal and (b) suboptimal habitat in the current survey are given. It is clear that the lamprey catch at sites considered to provide optimum habitat was significantly higher than at sites considered to present suboptimal habitat. In Table 8 summary statistics for the habitat parameters of the adjoining river sections to sites considered to present both optimal and suboptimal habitat are given. Table 8 presents the corresponding summary statistics for the micro-habitat parameters. Difference in the physical habitat values obtained for both rated habitats suggest that the optimum lamprey nursery habitats on the Boyne are present at lower altitudes and in areas of greater river width and lower bank height and slope. This reflects the fact that optimal habitats were present at a greater frequency in the undrained reaches of the lower Boyne than in other areas of the catchment. Optimal habitats also had a greater percentage of pool habitats and a lower percentage of instream vegetation cover than sub-optimal habitats. This again reflects the greater occurrence of optimal habitats on undrained sections of river in the Boyne catchment. On the microhabitat scale, optimal lamprey habitats on the Boyne were slightly shallower and more shaded than sub-optimal sites and had a lower flow. Sub-optimal sites had a much greater occurrence of clay. Boulder clay is exposed on many of the Boyne tributaries which were drained during the 1980's.

Table 5 Assessment of Favourable Conservation Status of lampreys (*Lampetra* sp.) in the Boyne catchment (based on the methodology of Harvey & Cowx, 2003).

River	**Abundance in? optimal habitats**	**Abundance on a sub-catchment basis**	**Population structure**	**Distribution**	**Evaluation**
Lower Boyne	Favourable	Favourable	Several cohorts present	Present at all sites	Favourable
Middle/Upper Boyne	Unfavourable	Favourable	Several cohorts present	Widely distributed	Favourable
Mattock and Devlins Rivers	Unfavourable	Favourable	Several cohorts present	Present at all sites	Favourable
Kells Blackwater/Moynalty downstream of Lough Ramor	Unfavourable	Favourable	Several cohorts present	Widely distributed	Favourable
Lough Ramor catchment	Unfavourable	Unfavourable	Restricted	Restricted	Unfavourable
Skane, Boycetown, and Knightsbrook Rivers	Unfavourable	Unfavourable	Restricted	Restricted	Unfavourable
Tremblestown and Stonyford Rivers	Unfavourable	Unfavourable	Several cohorts present	Present at all sites	Unfavourable
Deel	Unfavourable	Favourable	Several cohorts present	Widely distributed	Favourable
Longwood Blackwater sub-catchment	Unfavourable	Favourable	Several cohorts present	Widely distributed	Favourable
Killwarden/Kinnegad and Garr Rivers	Unfavourable	Favourable	Two or more age groups present	Widely distributed	Favourable
Castlejordan/Yellow/Monga Rivers	Unfavourable	Favourable	Several cohorts present	Widely distributed	Favourable
Overall evaluation					**Favourable**

Table 6 Summary statistics for lamprey catch at sites where habitat was considered to be optimal (n = x) and where habitat was considered suboptimal (n = y).

Lamprey catch	Optimal	Sub-optimal
Mean Density (no. per m²)	12.85	1.24
Min. Density (no. per m²)	0.67	0.00
Max. Density (no. per m²)	79.00	11.40
St. Dev.	16.64	1.88

Table 7 Summary statistics for the habitat parameters of the adjoining river sections to sites considered to have optimal or suboptimal habitat.

Habitat Assessment	Optimal	Sub-optimal
Site Altitude (m)	43.20	62.80
Wetted width(m)	16.55	8.79
Bank height(m)	2.82	4.25
Mean depth(cm)	59.06	53.20
Maximum depth(cm)	75.85	71.56
Bank cover (%)	88.28	87.46
Canopy cover (%)	13.34	16.38
Bank slope(degrees)	59.22	66.53
Riffle (%)	9.97	11.61
Glide (%)	50.41	59.07
Pool (%)	39.63	28.98
Vegetation cover (%)	20.94	33.88
Shade (%)	20.44	25.93
Fine Substrate (%)	18.13	22.50
Gravel Substrate (%)	24.79	22.09
Cobble Substrate (%)	33.33	23.67
Flow (cms^{-1})	9.45	9.62

Table 8 Summary statistics for the micro-habitat parameters of the areas fished at sites considered to have optimal and suboptimal habitat.

Habitat Assessment	Optimal	Sub-optimal
Mean depth (cm)	25.63	27.37
Sand (%)	34.38	29.57
Silt (%)	57.81	56.95
Clay (%)	6.56	10.85
Density (index)	2.58	2.60
Shade (%)	41.72	38.28
Rooted vegetation cover (%)	23.44	24.58
Flow (cms^{-1})	1.81	2.47

Table 9 Density estimations (fish m^{-2}) for lampreys at the four quantitative sites.

Site	Equation	R^2	Population estimate	Area (m^2)	Density (lamprey m^{-2})
Q1	y = -3.1531x + 182.96	0.99	58	7.50	7.70
Q2	y = -11.714x + 430.14	0.91	37	4.00	9.18
Q3	y = -5x + 66	0.97	13	5.00	2.64
Q4	y = -4.0087x + 348.36	0.96	87	5.70	15.25

4.5 Quantitative Electrical Fishing Assessments

Quantitative assessments were undertaken at four sites (Lower Boyne, Kells Blackwater, Riverstown and Longwood Blackwater Rivers). The locations of the quantitative sites are provided in Figure 1 and Appendix 1. The results of these assessments are provided in Figure 8 and Table 9 (previous page). During the quantitative electrical fishing assessments an overall 82% of the lampreys present in the four sites were captured during the first fishing. This is considered to be a very high efficiency.

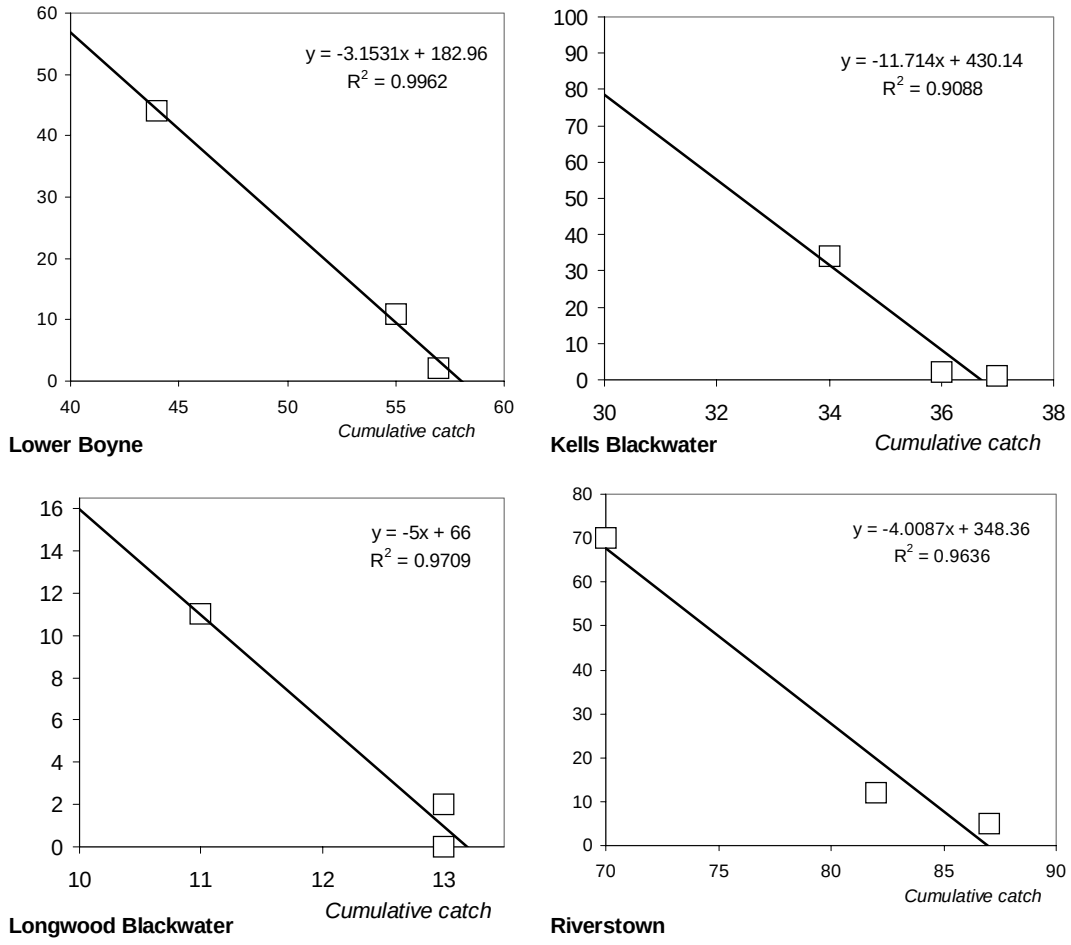


Figure 8 Results of the quantitative electrical fishing investigations at three sites. Catch is plotted against cumulative catch (Leslie-Davies method). Depletion lines for the total numbers of juvenile lamprey captured are given for the four sites.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The current survey has confirmed that significant populations of river/brook lampreys occur throughout the River Boyne catchment. It is likely that populations in the lower reaches of the river include *Lampetra fluviatilis* while *Lampetra planeri* is likely to be the dominant species in more up river areas. Sea Lampreys may also be present in the lower reaches of the river, but were not detected during the current survey.

Juvenile lampreys exhibiting an unusual pigmentation pattern, somewhat similar to that reported for sea lamprey ammocoetes, were found in the middle and upper reaches of the Boyne and on tributaries other than the Kells Blackwater and Mattock. This caused some confusion when examining ammocoetes under field conditions. However, detailed laboratory examination, including counting of trunk myomeres of a sample of 200 lampreys collected from eight sites around the catchment, confirmed that these lampreys were in fact *Lampetra* sp. individuals. It is likely that the specimens exhibiting the unusual pigmentation type were in fact resident *Lampetra planeri*. If sea lampreys were present in the river, it would seem likely that there would be a greater chance of recording them at sites in the lower river – particularly downstream of barriers such as weirs. However no sea lampreys (or indeed lampreys with the unusual pigmentation type discussed above) were recorded at the sites at Obelisk Bridge, Curly Hole, Newgrange and Rossnaree in the lower River Boyne (total sample size = 208). Likewise, no lampreys with the unusual pigmentation type were recorded on the Mattock tributary which enters the freshwater tidal reaches of the Boyne (total sample size = 234). The current investigation has concluded that identification of ammocoetes on the basis of their pigmentation can be difficult under field conditions. It is therefore recommended that in future surveys, regular myomere counting should be undertaken where ammooetes with unusual pigmentation patterns are found to provide an unambiguous method of identification.

Lamprey populations in the Boyne catchment are considered to be at a favourable conservation status in most areas, with the exception of some of the tributaries of the middle Boyne (Stonyford, Tremblestown, Skane, Boycetown and Knightsbrook Rivers) and in the Kells Blackwater catchment upstream of Lough Ramor. The River Boyne main channel downstream of Navan and the middle reaches of the Kells Blackwater River were not directly affected by the 1980s arterial drainage scheme in the catchment. Lamprey stocks in these areas are in a very healthy state with high densities of larvae present in all suitable habitats investigated. Several cohorts of juvenile lampreys were also present at each site investigated confirming that regular recruitment occurs in these areas. Lamprey stocks in other areas of the catchment were less abundant and diverse but were still considered to be at a favourable conservation status level (with the exception of the areas mentioned above). It is clear that areas affected by the arterial drainage scheme have a much reduced availability of lamprey habitats and that little physical recovery has occurred on many of the smaller channels over the past 20 years.

No definite relationship between water quality and lamprey numbers was apparent during the current survey. The highest densities recorded were in the lower River Boyne, which was also the most polluted area surveyed. It is clear that lamprey ammocoetes are fairly tolerant to moderate levels of organic pollution and appear to thrive under these conditions. However, it is likely that if pollution levels on the lower Boyne and in other areas of the catchment continue to increase that lamprey will be eventually lost from these areas.

A total of 42 ammocoetes recorded during the current survey were classified as transformers. Most of these were recorded during the assessment of the eight index sites in September. Most of the transformers collected were in the earlier stages of transformation and no definite identification could be made for any of the transformers captured. It was concluded however that all the transformers collected during the September were more likely to be *Lampetra planeri*. It is certain that by surveying sites later in the year (i.e. October - November) lampreys in later stages of transformation could be collected and these would be easier to identify. Surveys at this time of the year could be limited to a

small number of index sites. Electrical fishing during winter is not normally approved by the fisheries boards. However, as lamprey microhabitats are generally located away from salmonid spawning areas work at this time of year at a number of carefully selected sites would not disturb salmonids.

It is concluded that the main lamprey populations in the River Boyne are currently protected within the existing SAC boundary area and no recommendations are made to extend the boundary area. The possibility of enhancing lamprey populations in the catchment through development works should be considered and provisions for lampreys should be included in any further development works undertaken by the fisheries board. Lamprey habitats can be encouraged to form by installing deflectors made of stone or logs along the sides of rivers. The deflectors create alcoves or backwaters where silt and other debris will settle. Planting of aquatic vegetation such as *Sparganium erectum* in these areas will further encourage silt to settle and shading can be created by planting *Salix* spp. on the bank. The root structures of the willows and reeds create ideal cover for ammocoetes. These areas should be fenced off from livestock and allowed to accumulate woody debris and silt.

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APPENDIX 1 List of sites investigated during the 2005 survey of the Boyne catchment.

Site Code	EPA code	Q-value 2003	River	Tributary	Location	Grid reference	Date surveyed	Lampreys present
B1	07/B/04/2200	3-4	Boyne		Obelisk Bridge	O04550 76200	20/07/2005	●
B2	07/B/04/2200	3-4	Boyne		Curly Hole	O03839 76124	20/07/2005	●
B3	07/B/04/2150	3-4	Boyne		Newgrange	O01249 72626	20/07/2005	●
B4	07/B/04/2150	3-4	Boyne		Glen House	N99683 71958	12/09/2005	●
B5	07/B/04/2100	3-4	Boyne		Slane Bridge	O96411 73725	20/07/2005	●
B6	07/B/04/2010	3-4	Boyne		Broadboyne Br.	N91728 71212	22/07/2005	●
B7	07/B/04/1900	3-4	Boyne		Athlumney	N88136 68313	22/07/2005	●
B8	07/B/04/1700	3-4	Boyne		Kilcarn Br.	N88497 65543	07/08/2005	●
B9	07/B/04/1600	3-4	Boyne		Ballinter Br.	N89374 62570	07/08/2005	●
B10	07/B/04/1500	3-4	Boyne		Bective Br.	N86031 59793	04/08/2005	●
B11	07/B/04/1400	3-4	Boyne		St. Peters Br., Trim	N81625 56826	04/08/2005	●
B12	07/B/04/1400	3-4	Boyne		Trim Castle	N80624 56409	14/09/2005	●
B13	07/B/04/1200	3-4	Boyne		Trim(upper Bridge)	N79847 57006	29/07/2005	●
B14	07/B/04/1200	3-4	Boyne		Tremblestown confluence	N77044 56586	29/07/2005	●
B15	07/B/04/1000	4	Boyne		Derryinydaly Br.	N76668 53924	03/08/2005	●
B16	07/B/04/0900	3-4	Boyne		Scariff Br.	N73437 52706	30/07/2005	●
B17	07/B/04/0900	3-4	Boyne		U/s Scarriff Bridge	N73052 52571	12/09/2005	●
B18	07/B/04/0800	4	Boyne		Inchantore Br.	N71098 49989	26/08/2005	●
B19	07/B/04/0800	4	Boyne		Stoneyford Br.	N68910 47347	13/09/2005	●
B20	07/B/04/0600	3	Boyne		Ashfield Br.	N68510 44808	13/09/2005	●
B21	07/B/04/0600	3	Boyne		Leinster Br.	N66559 43729	13/09/2005	●
B22	07/B/04/0400	4	Boyne		Ballyboggan Br.	N63905 40229	27/07/2005	●
B23	07/B/04/0300	3	Boyne		Kinnafad Br.	N61431 35010	28/07/2005	●
B24	07/B/04/0200	3	Boyne		Boyne Br. (Edenderry)	N63677 37542	28/07/2005	●
B25 (A)	07/B/04/0200	3	Boyne		Kishawanny Bridge	N64595 33445	28/07/2005	●
B25 (B)	07/B/04/0200	3	Boyne		Kishawanny Bridge	N64595 33445	13/09/2005	●
B26	07/B/04/0200	3	Boyne		Br. u/s Kishawanny br.	N65306 32885	13/09/2005	●
B27	07/B/04/0200	3	Boyne		River Br. (Edenderry)	N66823 32737	06/08/2005	●
M1	07/M/01/0300	4	Mattock		New Br.	O03687 75666	21/07/2005	●
M2	07/M/01/0200	4	Mattock		Mattock Br. (N51)	O01249 75090	21/07/2005	●
M3	07/M/01/0200	4	Mattock		Melifont Br.	O01387 78330	21/07/2005	●
M4	07/D/02/0200		Devlin's		Devlin's Br.	N97985 76819	08/08/2005	●
Sk1	07/S/01/0600	3-4	Skane		Dowdstown Br.	N90399 62299	07/08/2005	
Sk2	07/S/01/0510	3-4	Skane		Bridge in Balgeeth	N89129 60090	07/08/2005	
Sk3	07/S/01/0300	2-3	Skane		Kilmessan Br.	N88988 57371	07/08/2005	
Bc1	07/B/03/0300	3	Boycetown		Scurlockstown Br.	N83243 56109	07/08/2005	
Bc2	07/B/03/0200	3	Boycetown		Milltown Br.	N85785 54204	08/08/2005	
Kn1	07/K/02/0500	3-4	Knightsbrook		Iffernock	N82841 55979	08/08/2005	●
Kb1	07/B/01/1790	3-4	Kells Blackwater		Navan	N86810 68212	22/07/2005	●
Kb2	07/B/01/1500	4	Kells Blackwater		Tatestown	N82577 71925	22/07/2005	●
Kb3	07/B/01/1500	4	Kells Blackwater		Donaghpatrick Br.	N81933 72307	19/07/2005	●
Kb4	07/B/01/1500	4	Kells Blackwater		Telltown	N01808 72520	08/08/2005	●
Kb5	07/B/01/1400	4	Kells Blackwater		Bloomsbury Br.	N79348 73977	19/07/2005	●
Kb6	07/B/01/1300	3-4	Kells Blackwater		Headford Br.	N76244 75978	19/07/2005	
Kb7	07/B/01/1200	3-4	Kells Blackwater		Maudlin	N74753 76721	14/09/2005	●
Kb8	07/B/01/1200	3-4	Kells Blackwater		Maudlin Br.	N74690 76791	19/07/2005	●
Kb9	07/B/01/1200	3-4	Kells Blackwater		Mabe's Br.	N73636 77317	19/07/2005	●
Kb10	07/B/01/1200	3-4	Kells Blackwater		Claven's Br. (N3)	N71614 77330	19/07/2005	●
Kb11	07/B/01/1100	3-4	Kells Blackwater		Carnacross	N68576 77929	22/07/2005	●
Kb12	07/B/01/1000	3	Kells Blackwater		O Daly's Br.	N65245 80340	22/07/2005	

APPENDIX 1 (Continued) List of sites investigated during the 2005 survey of the Boyne catchment.

Site Code	EPA code	Q-value 2003	River	Tributary	Location	Grid reference	Date surveyed	Lampreys present
Kb13	07/B/01/0900	3	Kells Blackwater		Lough Ramor Outflow	N63078 83347	21/07/2005	
Kb14	07/B/01/0800	4	Kells Blackwater		Murmod Br.	N59967 88857	25/08/2005	●
Kb15	07/B/01/0600	3-4	Kells Blackwater		Stramaquerty Br.	N59479 92125	25/08/2005	
Sw			Kells Blackwater	Swiftbrook	Bridge on R194	N59080 88159	25/08/2005	
Moy 1	07/M/03/0900	3-4	Kells Blackwater	Moynalty	Fyanstown Bridge (R163)	N79041 75766	21/07/2005	●
Moy2	07/M/03/0900	3-4	Kells Blackwater	Moynalty	Rossmeen	N79102 77157	21/07/2005	●
Moy 3	07/M/03/0800	3-4	Kells Blackwater	Moynalty	Mahonstown Br.	N73375 82684	21/07/2005	
Moy4	07/M/03/0600	3-4	Kells Blackwater	Moynalty	Moynalty	N75350 80429	21/07/2005	●
Tm1	07/A/01/0500	4	Tremblestown		Kilnagross Br.	N76987 56718	29/07/2005	●
Tm2	07/A/01/0400	3-4	Tremblestown		Tremblestown Br.	N75517 57672	29/07/2005	●
Tm3	07/A/01/0200	3-4	Tremblestown		Otterstown Br.	N72826 62775	29/07/2005	●
Tm4	07/A/01/070	4	Tremblestown		Kilkeelan	N70827 66631	29/07/2005	●
S1	07/S/02/0400	4	Stonyford		Stonyford Br.	N73155 53193	30/07/2005	●
S2	07/S/02/0300	4	Stonyford		Shanco Br.	N70550 54714	30/07/2005	●
S3	07/S/02/0300	4	Stonyford		Earl's Br.	N69364 65097	30/07/2005	●
S4	07/S/02/0090	4	Stonyford		Woodtown (u/s Cloghbrack Br.)	N67209 58812	29/07/2005	●
S5	07/S/02/0070	4	Stonyford		N51 Bridge, 2km east of Devlin	N62110 62502	29/07/2005	●
Lb1	07/B/02/0400	3-4	Longwood Blackwater		R160 Bridge	N72174 45210	27/08/2005	●
Lb2	07/B/02/0100	4	Longwood Blackwater		Johnstown, 200m u/s R402 Br.	N76692 39921	27/07/2005	●
Lb3	07/B/02/0060	3	Longwood Blackwater		Bishop's Chair Br.	N80971 36921	27/07/2005	●
Lb4	07/B/02/0050		Longwood Blackwater		Blackwater Br.	N81635 34248	27/07/2005	●
Lb5	07/B/02/0050		Longwood Blackwater	Fear English	Kilmurry	N74916 38213	27/08/2005	
D1	07/D/01/0600	3-4	Deel		Ballyadams (R161 Br.)	N69035 49289	04/08/2005	
D2	07/D/01/0400	3-4	Deel		Inan Br.	N63498 50361	04/08/2005	●
D3	07/D/01/0300	3	Deel		Raharney	N60126 52984	05/08/2005	
D4	07/D/01/0200	3-4	Deel		Cummer Br.	N58453 57553	05/08/2005	●
D5	07/D/01/0200	3-4	Deel		Ballynacor Br. (N52)	N57909 60207	05/08/2005	●
D6	07/D/01/0090	3-4	Deel		Mooretown Br.	N56425 62541	05/08/2005	
D7	07/D/01/0070	3-4	Deel		Drumcree	N55763 65404	25/08/2005	●
K1	07/K/01/0300	3-4	Kilwarden		Clonard Br.	N65771 44866	25/08/2005	●
K2	07/K/01/0100	3	Kilwarden	Kinnegad	Kinnegad (R161)	N60280 45261	05/08/2005	●
G1			Garr		Ballindoolin	N64360 38260	06/08/2005	
Y1	07/Y/02/0300	4	Yellow		Clongall Bridge	N59455 37552	28/07/2005	●
Y2	07/Y/02/0300	4	Yellow		Sheep Bridge	N58188 38625	05/06/2005	●
Y3	07/Y/02/0100	3-4	Yellow		Garr Bridge	N53170 36896	05/08/2005	
Y4	07/Y/02/0100	3-4	Yellow	Castlejordan	Castlejordan Bridge	N59027 38703	05/08/2005	●
Y5	07/Y/02/0100	3-4	Yellow	Castlejordan	Balintoran Bridge	N55293 40820	05/08/2005	●
Q1	07/B/04/2010	3-4	Boyne		D/s Broadboyne Br.	N92133 71517	26/08/2005	●
Q2	07/B/01/1400	4	Kells Blackwater		Bloomsbury Bridge	N79348 73977	26/08/2005	●
Q3	07/B/02/0600	3-4	Longwood Blackwater		R161 Br.	N71303 50087	27/08/2005	●
Q4	07/R/01/0100	3	Deel	Riverstown	Riverstown Br.	N56564 50830	27/08/2005	●

APPENDIX 2 Length descriptive statistics for lampreys captured at each site.

Table A2.1 Boyne main channel.

Site	N	Mean	Min	Max	St.Dev.	95% C.I.
B1	27	7.8	4.6	10.5	1.5	0.6
B2	26	5.7	4.1	9.1	1.5	0.6
B3	50	5.7	3.4	9.6	1.7	0.5
B4	105	7.4	4.8	11.7	1.6	0.3
B5	79	6.6	4.3	11.0	1.9	0.4
B6	17	7.6	4.5	11.8	2.9	1.4
B7	105	8.7	4.3	13.5	2.4	0.5
B8	45	10.5	4.6	13.8	2.0	0.6
B10	16	10.7	2.6	12.9	3.1	1.5
B11	5	10.6	8.4	11.6	1.3	1.1
B12	57	8.0	4.9	12.9	2.6	0.7
B13	29	6.7	4.6	11.2	1.9	0.7
B14	8	8.2	5.7	11.3	1.6	1.1
B15	1	10.1	10.1	10.1		
B16	3	10.7	9.8	11.7	1.0	1.1
B17	1	8.6	8.6	8.6		
B18	12	10.3	6.7	12.6	2.0	1.1
B19	23	9.8	6.4	13.0	1.8	0.8
B20	14	10.3	5.0	14.1	2.8	1.4
B21	11	10.1	7.9	13.5	1.7	1.0
B22	24	7.6	4.5	11.2	2.1	0.8
B23	2	14.4	14.3	14.4	0.1	0.1
B24	3	10.0	6.1	15.2	4.7	5.3
B25a	8	11.9	5.1	16.7	4.5	3.1
B25b	7	12.5	6.8	15.0	3.6	2.6
B26	2	12.3	10.7	13.8	2.2	3.0
B27	4	10.4	7.4	13.9	3.4	3.3

Table A2.2 Kells Blackwater.

Site	N	Mean	Min	Max	St.Dev.	95% C.I.
Kb1	17	8.8	4.8	13.4	3.4	1.6
Kb2	23	9.4	4.8	13.2	2.9	1.2
Kb3	22	6.8	4.2	12.5	2.8	1.2
Kb4	2	11.4	9.6	13.1	2.5	3.4
Kb5	21	5.9	4.4	10.1	1.7	0.7
Kb7	33	10.2	4.2	13.9	3.1	1.1
Kb8	25	11.0	0.5	15.8	3.6	1.4
Kb9	48	11.0	5.4	16.6	2.6	0.7
Kb10	16	11.0	4.7	17.2	3.5	1.7
Kb11	13	12.0	6.3	16.2	3.4	1.8
Kb 14	2	10.8	10.5	11.0	0.4	0.5

Table A2.2 (Continued) Kells Blackwater.

Site	N	Mean	Min	Max	St.Dev.	95% C.I.
Moy1	5	9.8	8.1	14.4	2.6	2.3
Moy2	2	15.2	12.7	17.7	3.5	4.9
Moy4	1	4.8	4.8	4.8		

Table A2.3 Other tributaries.

Site	River	Tributary	N	Mean	Min	Max	St.Dev.	95% C.I.
D2	Deel		5	9.7	7.7	11.2	1.5	1.3
D4	Deel		55	8.8	5.4	12.8	1.8	0.5
D5	Deel		10	11.4	9.2	13.1	1.1	0.7
D7	Deel		6	13.2	9.5	15.7	2.3	1.9
K1	Kilwarden		20	10.5	6.3	13.8	2.4	1.0
K2	Kilwarden	Kinnegad	16	10.8	6.8	13.7	2.0	1.0
Kn1	Knightsbrook		13	10.7	5.3	14.5	3.6	1.9
Lb1	Longwood Blackwater		75	7.0	3.8	12.7	2.5	0.6
Lb2	Longwood Blackwater		29	7.3	4.1	15.7	3.2	1.2
Lb3	Longwood Blackwater		12	4.6	3.2	7.5	1.5	0.9
Lb4	Longwood Blackwater		1	15.1	15.1	15.1		
M1	Mattock		76	10.2	4.9	15.2	1.9	0.4
M2	Mattock		71	8.3	4.8	15.2	2.4	0.6
M3	Mattock		18	10.7	6.5	15.2	2.4	1.1
M4	Mattock	Devlins	69	10.6	7.8	14.8	1.6	0.4
Q4	Deel	Riverstown	87	7.8	1.6	12.5	2.7	0.6
S1	Stonyford		12	11.6	9.5	13.5	0.9	0.5
S2	Stonyford		8	10.4	6.7	13.2	2.2	1.6
S3	Stonyford		17	7.7	4.6	13.1	2.4	1.1
S4	Stonyford		9	11.9	9.5	13.5	1.1	0.7
S5	Stonyford		2	8.1	7.6	8.6	0.7	1.0
Tm1	Tremblestown		10	11.9	8.4	15.7	2.3	1.4
Tm2	Tremblestown		3	14.0	13.9	14.1	0.1	0.1
Tm3	Tremblestown		26	12.9	9.6	16.4	1.8	0.7
Tm4	Tremblestown		25	9.1	4.8	14.1	2.7	1.1
Y1	Yellow		65	7.5	4.1	12.3	1.8	0.4
Y2	Yellow		30	11.1	1.8	14.3	2.6	0.9
Y4	Yellow	Castlejordan	1	10.1	10.1	10.1		
Y5	Yellow	Castlejordan/Monga	1	10.7	10.7	10.7		