# The status and distribution of lamprey in the River Barrow SAC

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DEPARTMENT OF THE ENVIRONMENT, HERITAGE AND LOCAL GOVERNMENT

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## Summary


- Investigations on distribution and status of juvenile lamprey were undertaken in the mains stem and tributary channels of the R. Barrow catchment in the period June – October 2004 using electric fishing techniques.

- During Phase I of the survey, undertaken during June – July, spot-fishing via electric fishing identified locations suitable for subsequent quantitative investigation.

- The Phase I results also identified the degree of sampling effort required in individual channels in the Phase II stage.

- A total of 75 locations were fished quantitatively in the Phase II operation between August and October. This phase generated information on presence-absence, population structure and population density.

- Sampling on the main stem of the R. Barrow was seriously handicapped by the excessive depth, for the sampling technique used, and by the prevalence of extensive rafts of aquatic plants growing out from the channel margins.

- In the majority of channels, investigations were carried out on more than one location in order to develop an understanding of juvenile lamprey status within or throughout a channel.

- 52% of the quantitative sampling sites generated negative results – with no juvenile lamprey recorded.

- A high proportion of the negative sites was recorded in tributaries discharging to the R. Barrow between Monasterevin and Carlow.

- Direct observation indicated than many tributaries contained a low proportion of the habitat features required by juvenile lamprey, particularly in regard to the occurrence of areas of deposition of fine-grained bed material.

- The vast majority of juvenile lamprey encountered was attributed to the genus *Lampetra*.

- While population density was low in many of the tributaries examined the combined populations of juveniles examined frequently displayed the presence of several year classes - an important point in terms of conservation management.

- Juveniles of *Petromyzon*, the sea lamprey, were taken at four stations, in four separate tributary channels. In all cases, numbers of *Petromyzon* were very low.

- In conservation management terms the findings are of concern in regard to both *Lampetra* spp. and *Petromyzon*. The occurrence of a high proportion of negative sites and of sites with low density of *Lampetra* is a cause of concern. Similarly, the very low level of *Petromyzon* records is also of concern.

# 1. Introduction

The three lamprey species recorded in Ireland, the brook (*Lampetra planeri* Bloch), river (*Lampetra fluviatilis* L.) and sea lamprey (*Petromyzon marinus* L.), are all listed on Annex II of the European Union (EU) Habitats Directive (92/43/EEC). This Directive obliges all member states to designate Special Areas of Conservation (SACs) for the protection of Annex II species. Member states must then ensure that favourable conservation status is maintained for the target species. The National Parks and Wildlife Service (NPWS) of the Department of Environment, Heritage and Local Government has responsibility under the Habitats Directive for the selection and conservation of SACs for lamprey in Ireland. Within the Irish implementing legislation (S.I. 94 of 1997), the Minister for Communications, Marine and Natural Resources is also identified as having a role in the conservation of specified fish species.

The desk study of Kurz and Costello (1999) compiled known anecdotal information and records on sightings and observations of the three lamprey species in Ireland. This provided a platform for NPWS to develop designations for proposed candidate SACs. The approach focused on those major channels discharging directly to the sea and in which there were records for all three species. The review of Kelly and King (2001) provided a synthesis of information on biology and ecology of the three lamprey species as well as identifying conservation requirements for Ireland. A further review of Igoe *et al.* (2004) also included recently collected information from discrete sites in some Irish waters.

However, in order to generate data to support SAC designations, as well as to identify current status and problems or issues pertinent to conservation of the target species, NPWS have initiated a programme of catchment-based surveys within the designated waters. An initial study was undertaken in 2003 focusing on the Slaney and Munster Blackwater SACs (King and Linnane 2004). While that study collected information on adult and juvenile phases of the three lamprey species, its findings clearly showed that investigation of juvenile population distribution, structure and density represented an optimal approach in terms of survey logistics. This view is also supported by recent studies from Scotland

(APEM 2004 a and b) and England (Harvey and Cowx 2003; Maitland 2003). In 2004, NPWS commissioned two further catchment-based studies, one on the Moy (O'Connor 2004) and one on the Barrow. This latter investigation is the subject of the present report.

## 2. Study Site – River Barrow catchment

The R. Barrow rises on sandstones in the Slieve Bloom Mountains at an elevation of 580 m. The river flows north-east and falls steeply from its upper reaches onto low-lying terrain. It then flows east as far as Monasterevin, where it is confluenced by a major sub-catchment (the Figile-Slate system) that flows over low-level terrain on limestone. From here, the much-enlarged river flows in an essentially southerly direction, confluencing with the R. Nore upriver of New Ross. The enlarged R. Barrow continues on its southerly route and merges with the R. Suir at Cheekpoint, forming Waterford Harbour below this point. The river is influenced by tide as far upstream as St. Mullins Weir, 32 km upstream from Cheekpoint. From Monasterevin to Carlow the channel flows over limestone and lies in an open landscape. However, the channel is bounded closely to the west by the Castlecomer Plateau from Carlow south to Goresbridge. The topography is further altered dramatically to the south of Goresbridge as the geology changes from limestone and the Barrow incises its way through a narrow gorge cut between the granite of the Blackstairs Mountains, immediately to the east, and the Brandon Hill granite, which dominates the landscape to the west (Whittow 1975).

The river falls steeply in its upper reaches, dropping 400m over an initial channel length of 10 km. The high mean gradient value of 4% gives way to mean values of 0.06% between Two-Mile Bridge and Monasterevin and a value of 0.02% from Monasterevin to Athy (Hogan 1939). Such low gradient values are indicative of a slow-flowing channel with predominance of deep, pool-type habitat or of continuous, deep glide habitat. The R. Barrow has been the subject of an arterial drainage scheme (1926 – 1934) with 210 km of main rivers and tributaries and 175 km of smaller drains deepened and widened, to improve conveyance, in the course of the works programme (Hogan 1939). The extent of the drainage programme was largely confined to the catchment upstream of Athy and included the extensive Figile-Slate systems. The drainage scheme identified the natural division of the catchment between the extensive areas of flat land upriver of Athy and the narrower, corridor-like character from Athy down to St. Mullins. The scheme as executed is currently maintained by the Barrow Drainage Board, composed of the three counties of Laois, Offaly and Kildare. Management involves retaining the channel conveyance as excavated in the original scheme. This process involves inchannel work, including removal of sediment deposits, fallen trees and other physical obstructions to passage of flood flow, and management of bank slopes to retain stability.

Downstream of Athy, the Grand Canal – Barrow Line navigation switches from being an exclusively canal-like channel to one where navigation takes place within the riverine channel. To accommodate navigation, as well as providing hydropower to a number of industrial units, the R. Barrow was regulated by a number of major weirs, creating a series of zero – very low gradient reaches between each weir. Navigation at each weir was accommodated through a network of lock gates. The navigation system is currently managed by Waterways Ireland. Their programme of management includes maintenance of the navigation channel within the R. Barrow's cross-section, a process that can require the removal of silt deposition and inchannel growths of tall emergent vegetation.

The tributary channels, as with the main stem, derive their character from local topography, geology, soil and land use. An extensive subcatchment is formed in the north-east of the Barrow system by the Cushina – Philipstown – Figile – Slate catchment. These channels drain extensive areas of flat land with large-scale commercial peat workings present. This subcatchment discharges to the Barrow at Monasterevin and is responsible for the considerable increase in cross-sectional form and dimensions of the main channel downstream of this confluence. The majority of channels discharging further downstream are relatively small, in terms of length and volume discharge, when compared to tributaries in neighbouring catchments such as the Slaney and Nore. Channels in the middle reaches flow over good agricultural land and have moderate gradients. The majority of those examined in this study had beds of cobble and had a uniform glide character with regular marginal growths of water celery. Many, such as the Stradbally, Boherbaun and Lerr were subject to channel maintenance. From Carlow south to Goresbridge the Barrow is flanked to the west by the ridge of high ground known as the Castlecomer Plateau, an area composed, geologically, of hard rock including Millstone Grits, shales and coal measures. Tributaries discharging from this area are short and are steep in their upper reaches. These include the Fusheoge, Old Leighlin and Acore. The group of tributaries discharging to the Barrow south of Goresbridge flow off granitic high ground. Some, such as the Aughavaud and Pollmounty, have a high gradient, torrential character with boulders and bedrock seams in the channel bed, as well as areas of sandy deposition. The Mountain River is a more extensive system with greater channel length, due to considerable meandering. While much of the main stem drains high ground at the slopes of the Blackstairs Mountains, the catchment also has a considerable lowland area. This latter includes the Black River tributary.

The overlying soils in the Barrow catchment reflect, in large measure, the underlying geology. The highlands of the Slieve Blooms consist of blanket peat and peaty gleys of sandstone origin (Gardiner and Radford 1980). These give way to gleys of limestone origin or to river alluvium in the catchment downstream to Monasterevin. The extensive area drained by the Slate and Figile systems, entering the main Barrow at Monasterevin, has soils of basin peat and of podzolics of limestone origin. From Monasterevin to Goresbridge, the principal soil association is one of grey brown podzolics, all of limestone origin. In the area between Athy and Goresbridge a narrow ribbon of soils is composed of morainic gravels and sands and these materials are extensively quarried in surface excavations. As with the geological changes at Goresbridge, so the soils also change and have their origins in granitic or Silurian glacial till or shales. The soil types from Athy down to the confluence with the R. Suir are all identified as excellent for tillage, with good sheep grazing soils on the granitic glacial tills.

Major commercial peat workings have been developed in the lowland areas to the north of the Slieve Blooms, around Portarlington and in the catchments of the Slate and Figile to the north of Monasterevin. South of Monasterevin, extensive areas of good farmland occur, both on low and on elevated ground. Grassland for grazing and silage production are common as is tillage production. Cereals and root crops were traditionally grown to service major brewing and sugar-beet production in Kilkenny and Carlow respectively.

Human settlement in the catchment has focussed on the R. Barrow and its river crossings. Carlow is the principal town and the ruins of the Norman castle at the river crossing is evidence of the importance of control of the water and its crossing points. Athy, further upriver, also has a fortified tower adjoining the bridge. At the tidal end of the R. Barrow, New Ross is a major harbour for import and export of goods. This town has also had a traditional manufacturing and industrial base dependant on the town's position as a port in tidal waters capable of handling large shipping.

Water quality has been monitored in the R. Barrow main stem and in selected tributaries by the Environmental Protection Agency (EPA) and its predecessors since 1971. Both chemical and biological variables have been measured. The biological monitoring involves assessment of the status of benthic macroinvertebrates in stony, shallow, fast flowing areas (riffles). Within each catchment, the EPA has established a network of such sites and a constant use of these sites permits comparison within-site over time and between sites. The main channel was surveyed in 2003 (Clabby *et al.*. 2004) and some overall improvement in water quality was reported when compared to data from 1997 and 2000. However, eutrophication continued to be widespread. The sources of this enrichment varied with location in the catchment. Agriculture and peat harvesting were identified in the upper reaches of the main stem and suspected sewage and other discharges were associated with the urban centres of Portlaoise, Portarlington, Monasterevin, Carlow and Bagenalstown.

The R. Barrow main channel is identified as an important amenity for waterside and water-borne activities. A national walking trail enables the enthusiast to walk or bike along the banks of the river. Management of the locks and navigation system permits pleasure cruisers to travel from the main line of the Grand Canal down via the Barrow Line and onto the open R. Barrow itself. This permits the intrepid navigator to, literally, go to sea down into the estuary via the St. Mullins locks and steam on past New Ross to Waterford or Dunmore East. The main stem and its tributaries support an angling fishery for salmon and trout while the main stem, in view of its depth and size, also supports areas of high-quality angling for coarse fish species. Trophy anglers regularly capture specimen pike from the Barrow (ISFC 2004). The Barrow is also unique in having, at present, the only known sizeable spawning population of twaite shad in Ireland. This fish, a member of the herring family, lives at sea or in the lower reaches of Waterford Harbour and ascends the Barrow to spawn in May each year downstream of the weir at St. Mullins. The ascending fish provide high quality sport for leisure anglers at that time of year and specimen twaite shad are commonly taken (ISFC 2004). This angling fishery provides a valuable service by way of acting as a 'barometer' on the status of shad populations.

As a consequence of the diversity of habitats and species present in the Barrow catchment, the Barrow corridor together with the adjacent R. Nore was selected in 1999 as an SAC by NPWS [SAC # 002162]. The SAC designation covers the main stem of the Barrow to its headwaters in the Slieve Bloom Mountains as well as a number of specified tributary channels. The three species of lamprey found in Ireland – brook-, river- and sea lamprey, are listed as qualifying interests for this SAC.

## 3. Materials and Methods

The survey programme took place during the period June – October 2004 and focused on juvenile lamprey. Sampling was done using electric fishing techniques and was undertaken in conditions of low-flow only. In all cases, the survey sought out areas of sediment deposition and fine-grained material in low velocity areas where wading was feasible. These habitat features are identified as characteristic for juvenile lamprey (Almeida and Quintella 2002; Maitland 2003).

The programme was undertaken in two phases, with the first being completed prior to commencement of the second. Phase I was intended as a 'reconnaissance' expedition designed to identify a range of suitable habitat, within the channels to be surveyed, from which could be selected a series of suitable locations for quantitative fishing. This phase involved a tour of the channels designated in the SAC using spot fishing to ascertain presence or absence of juvenile lamprey. A Safari (Model RESEARCH 550d) backpack electric fishing unit was used throughout the survey. Fishing effort was the same as that used in a similar CFB study in 2003 (King and Linnane 2004) where fishing was done at a rate of 1 minute per metre of bank length over suitable fine-grained terrain. Juvenile lamprey collected were retained until the completion of the fishing effort. The length and width of the area fished was measured using a flexible tape. A minimum density estimate (Crisp *et al*. 1974) was developed by division of number captured by surface area fished. In some sites, more than one 'patch' of sediment was surveyed. This occurred when several sediment patches were available in close proximity. Some areas of sediment appeared suitable for ammocoetes but, on fishing, did not yield any juvenile lamprey. In these cases, an adjacent patch of sediment was also examined. The availability of proximal patches permitted an overview assessment of the nature of the ammocoete distribution.

Site selection in Phase II was informed by the findings from Phase I. In addition, sampling stations were, where appropriate, located adjacent to monitoring stations used by the EPA for its water quality monitoring programme, based on invertebrate assemblages. Sampling sites were selected only where characteristic habitat attributes for juvenile lamprey were present –fine-grained sediment deposits with low water velocity in sheltered, marginal or backwater areas of the channel. The Phase II programme was based on depletion fishing within a sampling enclosure of 1 m X 1 m. This approach has been used in the UK in trials to develop a standardised sampling approach for juvenile lamprey (Harvey and Cowx 2003). The enclosure was composed of fine mesh (3mm X 3mm), rugged cloth netting sewn together to form four sidewalls. Each corner had four plastic rings sewn in, permitting the enclosure to be splayed out and stabilised through four steel poles, driven into the sediment to secure the enclosure firmly. An electrified landing net delivered current to the area inside the enclosure on a pulsed basis. Four depletion passes, at most, were undertaken at each site. In each pass, twenty-second bouts of fishing were followed by five-second rest periods. The stop-start approach was intended to draw juvenile lamprey from the bed material and discourage animals being trapped by continuous application of current. One team member carried out the fishing while the other recorded time intervals and used a non-electrified landing net of fine mesh to capture juveniles that emerged and evaded the electrified net. All juveniles from any pass were retained separately from those of other passes. On completion of all passes, juveniles were anaesthetised using Phenoxyethanol. This permitted an accurate measurement of length and examination using hand lens to distinguish juvenile sea lamprey from juvenile river/brook lamprey (after Gardiner 2003). Total numbers collected in each pass were used to assess population density and 95% confidence intervals using the method of Carle and Strub (1978). Once measured, juveniles were allowed to recover in fresh water prior to replacement into the area of capture.

Estimation of age and enumeration of year classes was based on the distribution of modal peaks in length frequency distributions generated for individual channels. The presence of very small specimens in autumn fishing events confirmed the presence of young-of-year fish. This approach followed that of Beamish (1980) and Beamish and Medland (1988).

The location of sites examined via electric fishing in Phase II was recorded using a GPS instrument (Garmin E-trex). In addition, water temperature was recorded using a thermistor, a water sample was retained for alkalinity and conductivity analysis and a sediment sample collected. Sediment was air-dried and sieved through a series of mesh sizes in a Retch electronic sieve stack. The fraction retained in each mesh size was weighed to permit compilation of cumulative percentage composition by weight.

# 4. Results

## 4.1 Phase I Spot-fishing survey

A total of 103 locations were examined covering, primarily, sites within the SAC. A visual assessment was considered appropriate to ascertain the appropriateness of electric fishing at any site. The visual assessment examined the habitat in term of low flow velocity, shallow (< 50 cm) water depth and availability of accumulations of fine-grained bed material. In many cases, a site visit identified the unsuitability of the site selected and required that a further site, or sites, be visited.

In the majority of channels, the initial inspection identified suitable habitat for electric fishing (Table 4.1). The Greese was an exception, where 16 sites were visited but only three were suitable for electric fishing. Other channels, where a large proportion of sites were viewed only, included the Old Leighlin and Owenass. The most common reason for not fishing a site was the absence of fine-grained sediment. The majority of unsuitable sites had bed material of cobble and would not be considered as suitable habitat for juvenile lamprey.

Many of the channels had sub-optimal habitat for juvenile lamprey, based on visual assessment. In these cases, substantial numbers of patches were frequently fished in order to assess the representativeness of initial results. In many channels, high numbers of negative sites ie. those with no juvenile lamprey present, were recorded in many of the patches fished (Table 4.1). Both the Acore and Mountain River contained *circa* 50% negative patches. However, they also contained patches with density values ranging between low and high. Four channels yielded no lampreys and 44 of the 97 sites sampled were negative. The extent of negative patches at sites influenced the focus of the survey in Phase II, in terms of effort and extent.

The majority of channels designated within the SAC were examined in Phase I. Exceptions included the Stradbally and Lerr channels. Channel maintenance work was being undertaken by the Barrow Drainage Board in upstream reaches of the Stradbally system at the time, causing discolouration in the water and impeding electric fishing. In the case of both channels, initial inspection did identify possible sampling sites for Phase II. Of the channels not lying within the SAC designation, the Greese had a very poor distribution of juvenile lamprey while the Burren River, which discharges to the Barrow in Carlow town, had relatively high density values at two patches fished. Of particular significance was the Black River or O' Sheas. This is a tributary of the Mountain River and confluences with this channel adjacent to Borris. Juvenile lamprey were captured in the three patches sampled, including a high value of 20 fish / $m^2$. Given the SAC designation attributed to the Mountain River and the non-designation of the Black, it was considered appropriate that enclosures be quantitatively fished in both channels during Phase II.

Phase I clearly flagged the difficulties inherent in sampling in the main channel of the R. Barrow itself. For survey purposes, the channel was divided into two parts, the length from source in the Slieve Blooms to Monasterevin and the section from Monasterevin down to St. Mullins at the top of the tidal limit. This division was based on the change in character of the channel at Monasterevin, where the major subcatchment of the Figile – Slate system, with a catchment area comparable to that of the upper Barrow main stem itself, increases the volume discharge and dimensions of the main channel. Ten sites were visited in the upper zone, of which four were fished. The remaining six sites were considered unsuitable for survey based on problems of access and of unsuitable bed material.

Much of the channel downstream of Monasterevin is deep and slow flowing and a number of zones in this sector were examined by boat. There was a persistent problem with trying to access the bank or shore, from which fishing could be conducted. In many cases there was a continuous mat of surface vegetation growing out from the water's edge for several metres, preventing sampling of the littoral zone. In other cases the depth at the water's edge was excessive in terms of safety and logistics to permit electric fishing to be done. This problem was further exacerbated downstream of Athy, where the Barrow navigation channel exits from its discrete canal and is formed, and maintained, within the confines of the river channel itself. Here, the channel is of uniform depth along one side, with appropriately steep bank slopes and it was not possible to electric fish in safety. Problems of access on the opposite bank were as described above. Of the eleven sites inspected by boat downstream of Monasterevin, two only were fished in Phase I (Table 4.1).

**Table 4.1 Summary data from Phase I electric fishing survey, June - July 2004**

| Channel | Sites visited | Sites fished | Viewed only | Patches surveyed | No. negative patches | % negative patches | Min density no/m$^2$ | Max density no/m$^2$ |
|---|---|---|---|---|---|---|---|---|
| ***Main channel*** | | | | | | | | |
| **u/s Monasterevin** | | | | | | | | |
| | 10 | 4 | 6 | 5 | 0 | 0 | 0.5 | 3 |
| **d/s Monasterevin** | | | | | | | | |
| | 11 | 2 | 9 | 2 | 1 | 50 | 0 | 1.5 |
| | | | | | | | | |
| ***Tributaries*** | | | | | | | | |
| **Acore** | 4 | 4 | 0 | 11 | 6 | 54.55 | 1.5 | 3 |
| **Aghavaud** | 4 | 4 | 0 | 5 | 5 | 100 | 0 | 0 |
| **Ballymurphy** | 3 | 3 | 0 | 6 | 1 | 16.67 | 3.5 | 4 |
| **Boherbaun** | 9 | 6 | 3 | 12 | 10 | 83.33 | 0.64 | 2.38 |
| **Burren *** | 2 | 1 | 1 | 2 | 0 | 0 | 4 | 5 |
| **Campile** | 3 | 2 | 1 | 3 | 3 | 100 | 0 | 0 |
| **Duiske** | 3 | 3 | 0 | 4 | 0 | 0 | 7.5 | 10 |
| **Fushoge** | 7 | 5 | 2 | 11 | 5 | 45.45 | 0.69 | 11.34 |
| **Glenlahan** | 3 | 1 | 2 | 1 | 1 | 100 | 0 | 0 |
| **Glenmore** | 1 | 0 | 1 | 0 | | | | |
| **Greese *** | 16 | 3 | 13 | 4 | 0 | 0 | 0.9 | 3 |
| **Maudlin** | 2 | 2 | 0 | 5 | 0 | 0 | 3 | 4 |
| **Mountain** | 4 | 4 | 0 | 8 | 5 | 62.5 | 1.17 | 2.83 |
| **O' Sheas/Black *** | 3 | 3 | 0 | 7 | 1 | 14.29 | 1 | 20 |
| **Old Leighlin** | 7 | 2 | 5 | 2 | 2 | 100 | 0 | 0 |
| **Owenass** | 7 | 2 | 5 | 5 | 3 | 60 | 3.6 | 4 |
| **Murglash** | 3 | 1 | 2 | 1 | 0 | 0 | 1.5 | 1.5 |
| **Pollmounty** | 1 | 1 | 0 | 3 | 1 | 33.33 | 0.5 | 3.5 |
| | | | | | | | | |
| **Total** | 103 | 53 | 50 | 97 | 44 | 45.36 | | |

* = signifies Non SAC Channel

## 4.2 Phase II Quantitative fishing survey

Quantitative sampling was undertaken in 75 enclosures of 1 $m^2$ during August – October 2004. Sampling effort was determined by findings from the Phase I sampling results. Non-SAC channels, such as the Black River, were included where findings from Phase I pointed to significant populations of juvenile lamprey.

39 of the 75 enclosures fished (52%), did not contain juvenile lamprey. In the majority of cases, a wide range of density values was encountered in individual channels. Despite sampling at several locations, some channels yielded negative results at all sampling stations.

The time-of-year of the survey provided access to samples of transforming ammocoetes – those juveniles undergoing a series of physical and physiological changes in developing from the borrowing ammocoete stage to the free-swimming young adult stage. Transformers were recorded in five channels in the Barrow catchment. These were identified as belonging to the river/brook grouping. The dentition was not sufficiently developed to differentiate between these two species. No sea lamprey transformers were captured.

The vast majority of juvenile lamprey captured were identified as river/brook lamprey, after Gardiner (2003). These could not be distinguished to species. Juvenile sea lamprey were recorded in four channels (Table 4.2 and see Section 4.2.6 below). Where reference is made below to ammocoete or juvenile lamprey it should be assumed that juveniles of the genus *Lampetra* are being referred to, unless otherwise stated.

The results below deal with the main stem of the R. Barrow followed by results from the tributaries, moving from source in the Slieve Bloom Mountains to the tidal reaches of the Barrow estuary. The tributary channels are allocated to one of four groups below - source to Monasterevin, Monasterevin – Carlow, Carlow – St. Mullins, channels discharging to the tidal R. Barrow.

**Table 4.2 Summary data from Phase II survey: mean and range of density values for juvenile lamprey. Presence of juvenile sea lamprey and of transformers is also indicated.**

| Channel Name | Date | No. sites | Mean Density no/m² | Range no/m² | No. negative sites | % negative sites | Brook/river juveniles | Sea juveniles | Transformers |
|---|---|---|---|---|---|---|---|---|---|
| **Barrow** | **9/10.04** | 18 | 0.67 | 0-5 | 14 | 77.78 | yes | no | **yes** |
| | | | | | | | | | |
| **Glenlahan** | **9.04** | 2 | 0.00 | | 2 | 100 | no | no | no |
| **Murglash** | **9.04** | 1 | 5 | | 0 | 0 | yes | no | no |
| **Owenass** | **9.04** | 4 | 9.00 | 0-27 | 2 | 50 | yes | no | **yes** |
| | | | | | | | | | |
| **Boherbaun** | **9.04** | 5 | 0.00 | 0 | 5 | 100 | no | no | no |
| **Stradbally** | **9.04** | 4 | 4.00 | 0-7 | 1 | 25 | yes | no | no |
| **Greese *** | **8.04** | 4 | 0.00 | 0 | 4 | 100 | no | no | no |
| **Lerr** | **8.04** | 3 | 0.33 | 0-1 | 2 | 66.67 | yes | no | no |
| | | | | | | | | | |
| **Burren *** | **8.04** | 1 | 0.00 | | 1 | 100 | no | no | no |
| **Fuseogue** | **8.04** | 3 | 33.00 | 0-66 | 2 | 66.67 | yes | **yes** | no |
| **Old Leighlin** | **8.04** | 2 | 6 | 0-12 | 1 | 50 | yes | no | no |
| **Acore** | **8.04** | 3 | 6.60 | 5-9 | 0 | 0 | yes | **yes** | **yes** |
| **Mountain** | **8/9/10.04** | 8 | 26.75 | 0-86 | 1 | 12.5 | yes | no | **yes** |
| **Black *** | **8/10.04** | 4 | 19.75 | 14-31 | 0 | 0 | yes | no | no |
| **Aughnabrisky** | **8.04** | 1 | 0.00 | | 1 | 100 | no | no | no |
| **Ballymurphy** | **8.04** | 3 | 6.33 | 0-10 | 1 | 33.33 | yes | no | no |
| **Duiske** | **8.04** | 3 | 32.67 | 14-60 | 0 | 0 | yes | **yes** | no |
| | | | | | | | | | |
| **Aghavaud** | **8.04** | 1 | 0.00 | | 1 | 100 | no | no | no |
| **Poulmounty** | **8.04** | 1 | 20.00 | | 0 | 0 | yes | no | no |
| **Maudlins** | **8.04** | 2 | 20.50 | 14-27 | 0 | 0 | yes | **yes** | **yes** |
| **Glenmore** | **8.04** | 1 | 65.00 | | 0 | 0 | yes | no | no |
| **Campile** | **8.04** | 1 | 10.00 | | 0 | 0 | yes | no | no |

*** : Asterisk denotes non-SAC channel**

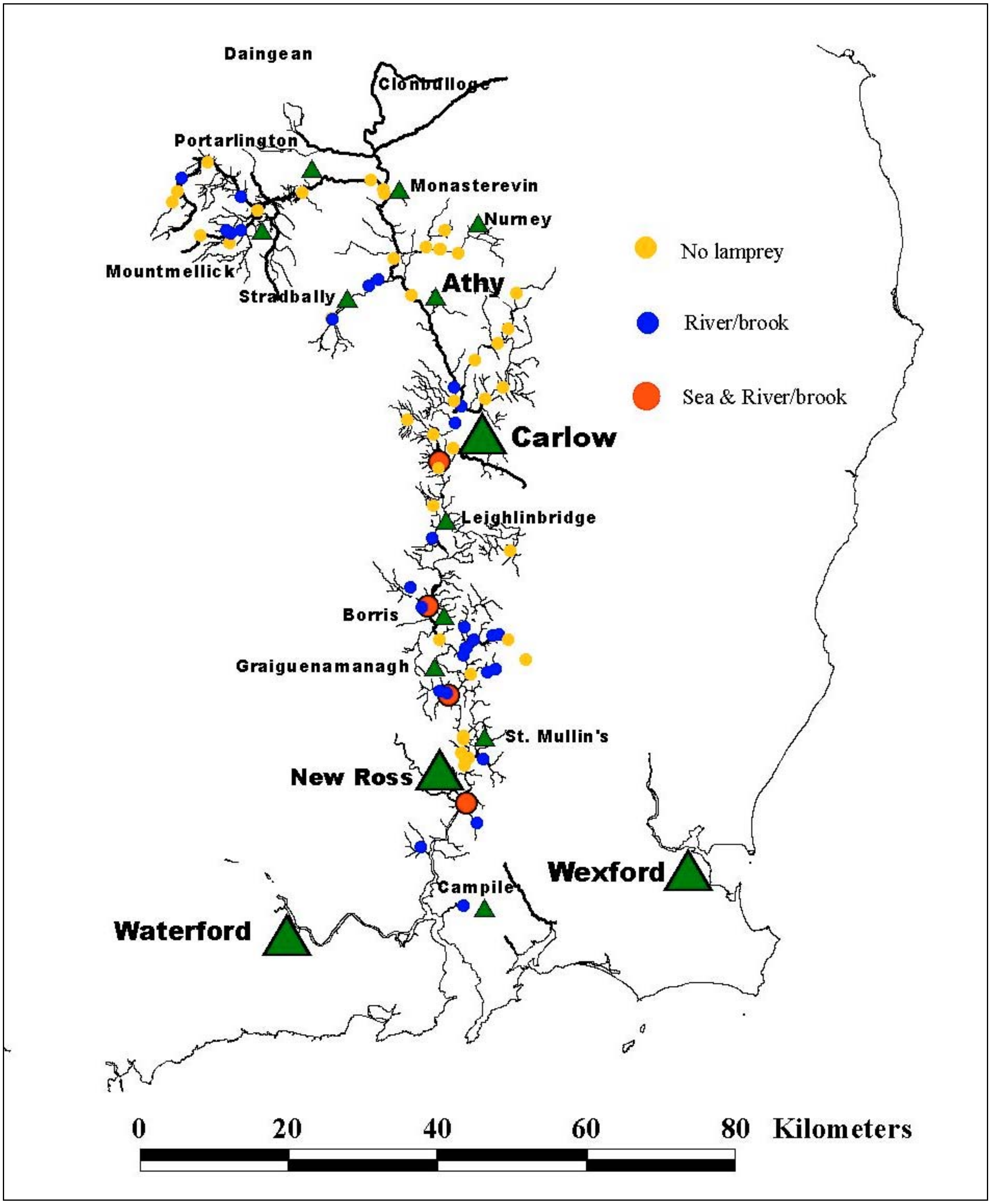



**Fig 4.1: Results of juvenile lamprey survey in the R. Barrow, 2004.**

### 4.2.1 River Barrow main stem

The difficulties associated with sampling along the margins of the main channel of the Barrow in this survey have already been described. These difficulties imposed a constraint on the number of sites surveyed. A final total of 18 enclosures were quantitatively fished in the main channel – six upstream of Monasterevin, five between Monasterevin and Carlow, two from Carlow to St. Mullins and five in the freshwater tidal reaches downstream of St. Mullins.

The majority of the sites yielded negative results, with juvenile lamprey captured at four locations – two upstream of Monasterevin and two between Monasterevin and Carlow (Fig. 4.1). At those sites where ammocoetes were found, density values ranged from 3 – 6 fish / $m^2$. The combined length data from the four positive sites, while extremely limited, did point to the presence of three size groups among the ammocoetes sampled (Fig. 4.2). This is considered indicative of three age groups. No young-of-year fish were captured. The length frequency distributions from the four individual sites confirmed the overview impression of three separate age groups among the ammocoetes captured.

Individual transformers of *Lampetra* were captured at two sites, one upstream of Monasterevin and one at Maganey. These could not be speciated at the time of year.

No ammocoetes of *Petromyzon*, the sea lamprey, were captured in any of the main channel sites examined.

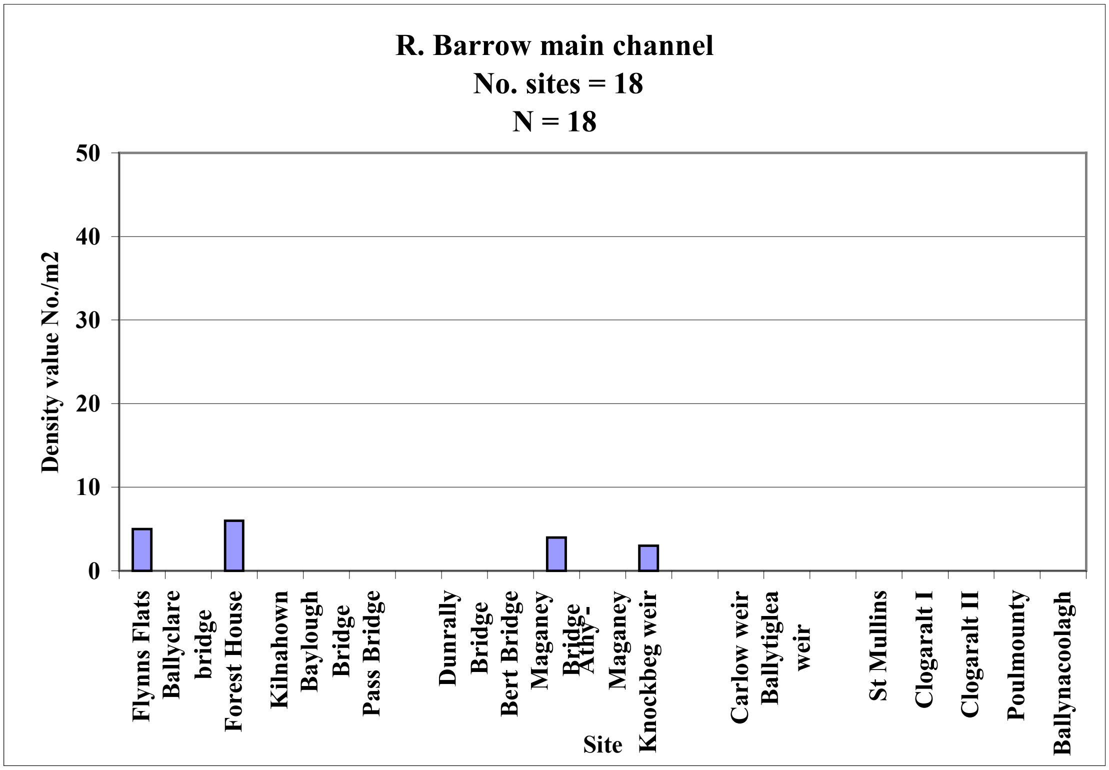



**Figure 4.1 Juvenile *Lampetra* density in R. Barrow main channel**

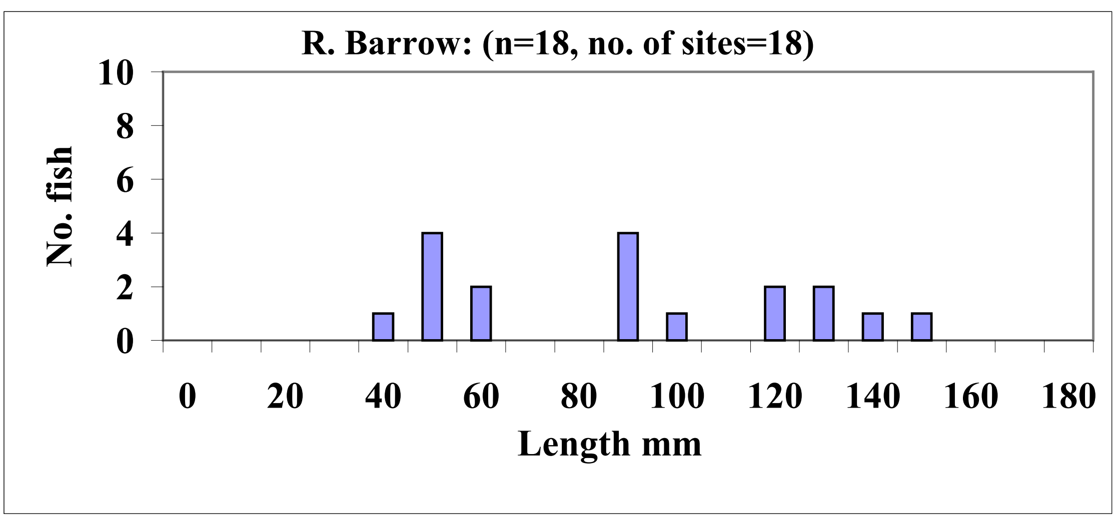



**Fig 4.2 R. Barrow: Length frequency of *Lampetra* ammocoetes**

### 4.2.2 Tributaries discharging between source and Monasterevin

***Glenlahan:*** This channel rises in the Slieve Bloom Mountains, close to the source of the R. Barrow and descends over steep terrain for approximately 6 km before joining the upper reaches of the R. Barrow proper near Clarahall. This upland terrain with high gradient would not be considered a likely area for deposition of fine-grained sediment. No juvenile lamprey were found in the two enclosures quantitatively fished here (Fig. 4.3).

***Owenass River catchment:*** The Murglash is a tributary of the Owenass channel. The single site examined had an ammocoete density of 5 fish/$m^2$ (Fig. 4.3). The small number of ammocoetes collected indicted the presence of at least two age groups (Fig. 4.4). A substantially greater number of ammocoetes were collected on the Owenass main channel, where four enclosures were fished. The density results indicated a very clumped, or uneven, distribution. Two of the four sites did not contain ammocoetes, while the other two sites had density values of 13 and 27 fish / $m^2$. (Fig. 4.3) The total sample from this channel spanned a range of lengths from 20 mm to 150 mm and the length frequency distribution showed the presence of a number of age groups. Both of the positive sites contained young-of-the-year amocoetes (Fig. 4.5). The site at Newmills was unusual in displaying a very wide, but uniform, distribution of sizes indicating the presence of a number of age groups. The Barkmills site contained a similarly wide range of length classes but the larger sample indicated a series of modal groups.

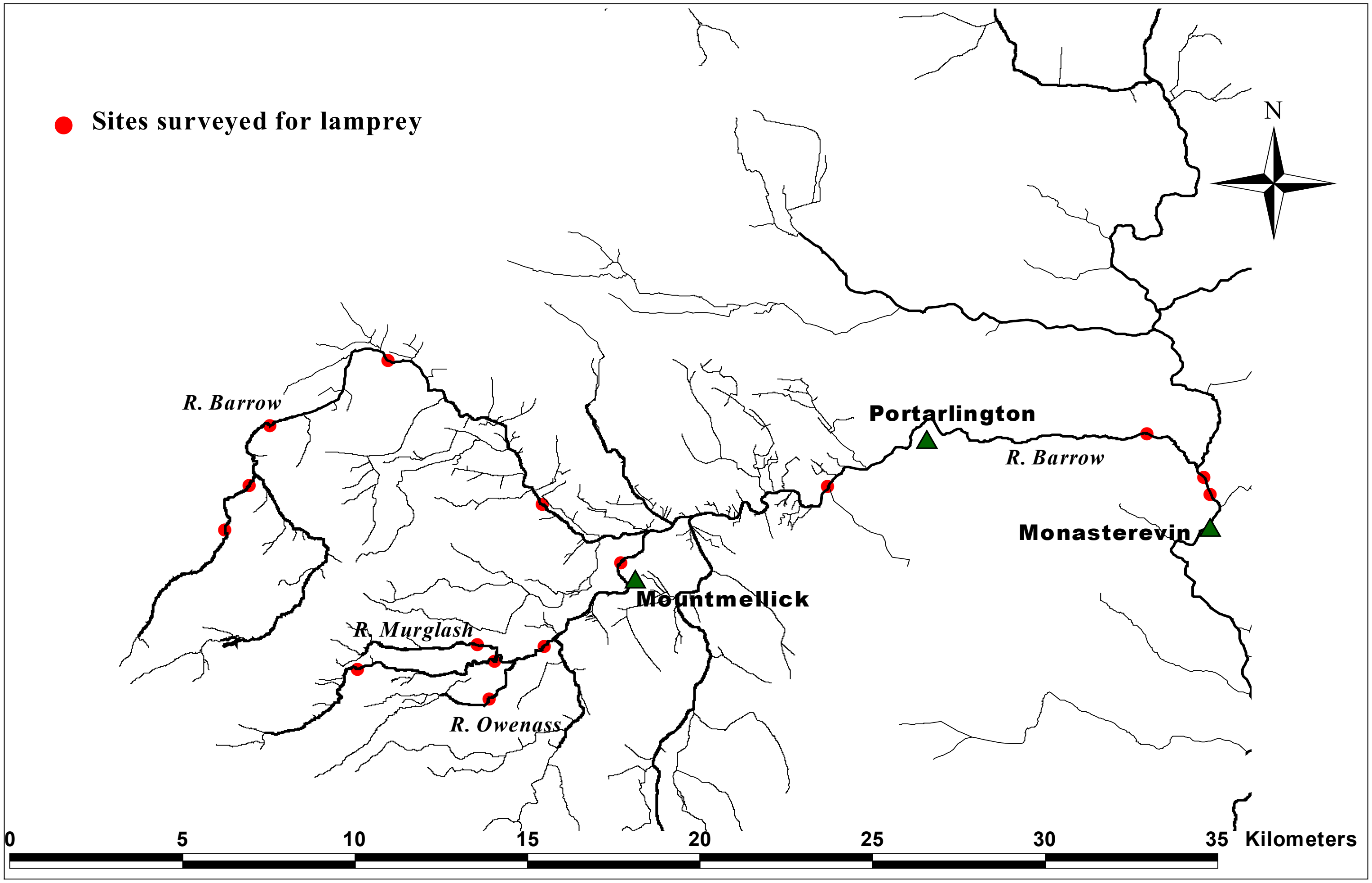



**Plate 4.2: Juvenile lamprey survey sites in the R. Barrow from source to Monasterevin, 2004.**

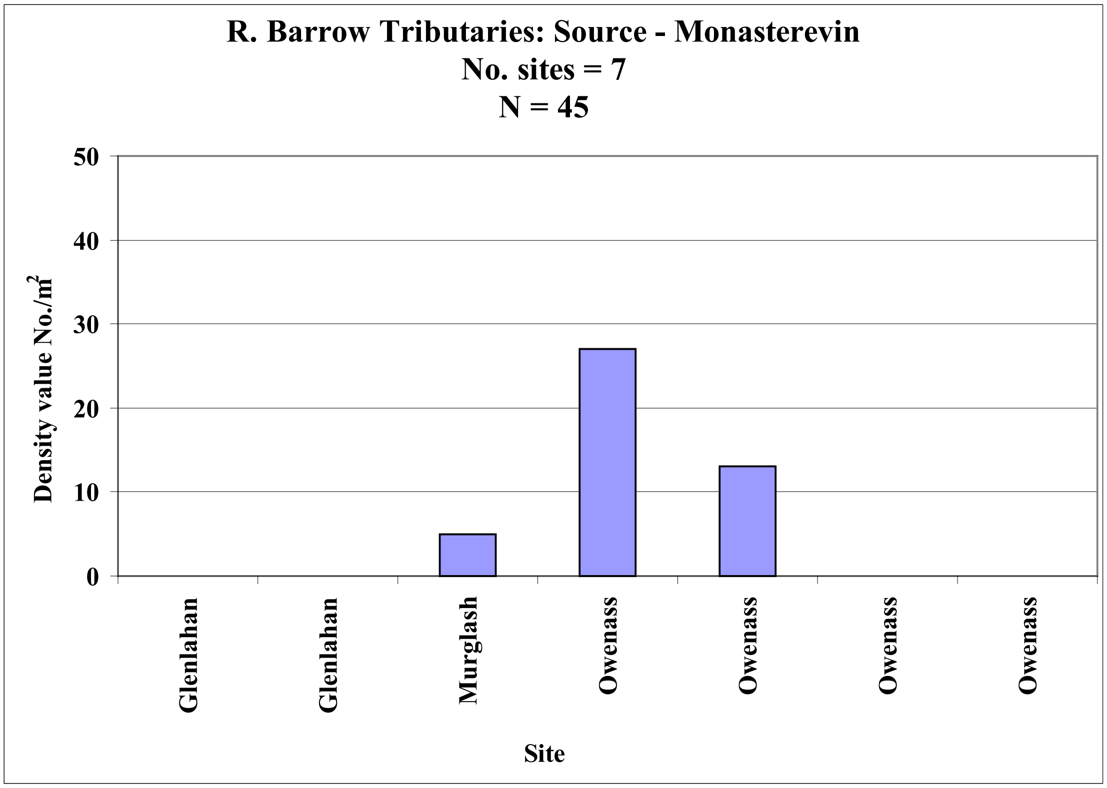



**Figure 4.3 Juvenile lamprey density in R. Barrow tributaries:Source - Monasterevin**

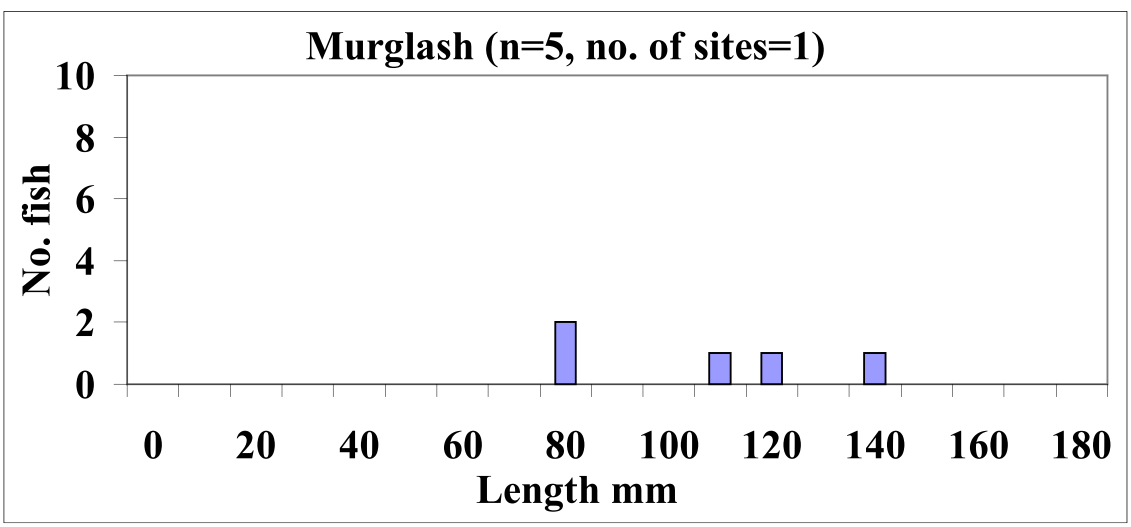
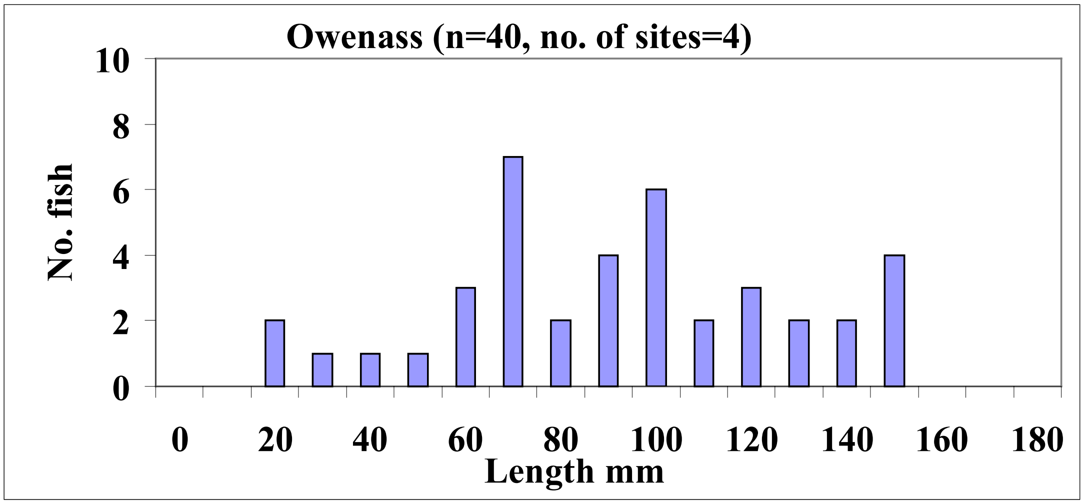
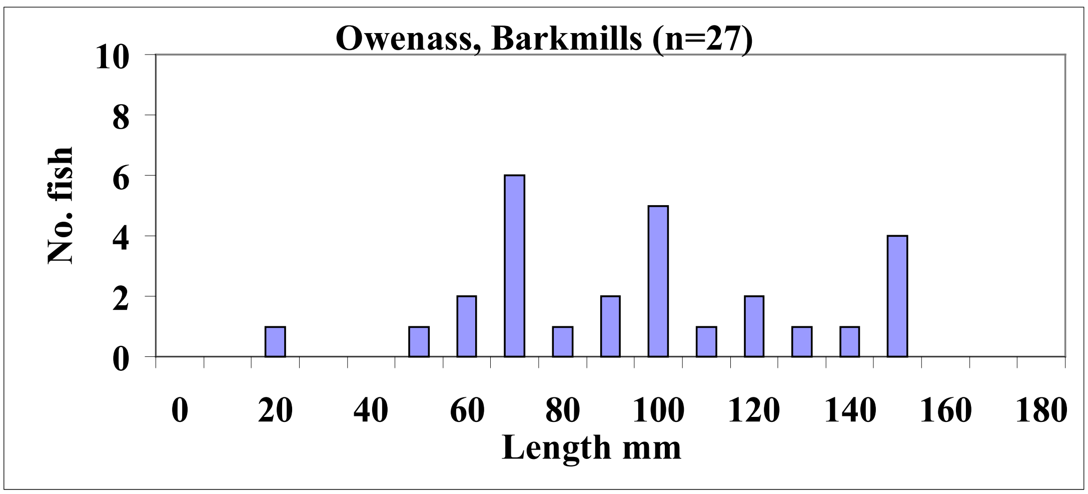



**Fig 4.4 R. Murglash: Length frequency of lamprey ammocoetes**



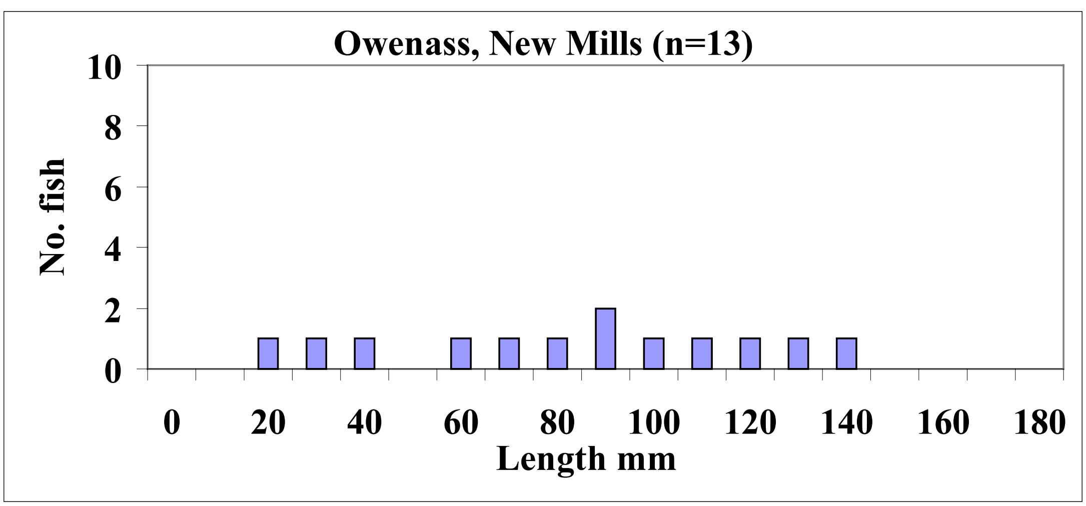




**Fig 4.5 R. Owenass: Length frequency of lamprey ammocoetes**

### 4.2.3 Tributaries discharging between Monasterevin and Carlow

***Boherbaun River:*** The hydraulic regime in this channel was one of uniform glide with stony, gravel-dominated bed over long reaches. It yielded few areas of sediment deposition suitable for juvenile lamprey habitat in the Phase I survey. In view of the length of channel designated, a series of five sites was quantitatively fished in September 2004 during the Phase II survey. All five sites proved negative (Fig. 4.6).

***Stradbally River:*** Within the designated SAC area, this channel was, visually, suitable habitat for Atlantic salmon spawning and nursery water. The bed was primarily composed of gravel – cobble material and areas of deposition that could function as ammocoete habitat were infrequent. Two sites were surveyed within the SAC, downstream of Stradbally village, as well as one site in each of the upstream tributaries – the Crooked and Bauteoge Streams. Of these two channels, the Bautoege had recently received maintenance by the Barrow Drainage Board while the Crooked Stream was a wide channel with a sandy, depositing bed. Density values ranged from zero to 7 fish/$m^2$ (Fig. 4.6). The combined sample size for the Stradbally system was very small (N = 18) but the population structure indicated the presence of at least three age groups, with modal peaks at 40 mm, 90 mm and 140 mm (Fig. 4.7).

The two sampling sites within the SAC both occurred at bridges, where limited areas of sediment accumulated. The site at the Grand Canal aqueduct contained a small cluster of ammocoetes, primarily of 80 – 110 mm while the site at Rahin Bridge clearly demonstrated the presence of three age groups in the small sample. The Crooked Stream yielded a number of large ammocoetes of 140 – 170 mm. The Bauteoge channel had an unsuitable bed material for ammocoetes. It had recently been maintained and did not yield any areas of sediment deposition. No juvenile lamprey was found in the site fished.

***R. Greese (Non SAC channel):*** While the Greese had a similar hydraulic and bed regime to the Boherbaun, Stradbally and Lerr channels, some areas of deposition were encountered. However, none of the four sites sampled yielded juvenile lamprey (Fig. 4.6).

***R. Lerr:*** This channel was surveyed at three locations between Castledermot and the confluence with the R. Barrow. These sites, in addition to other locations viewed, were characterised by a moderate gradient and a bed dominated by cobble and gravel. The margins frequently carried stands of water celery-type vegetation that served to accelerate open channel velocity. Areas of sediment deposition were not common either in open water on in the channel margins. A single juvenile lamprey was captured at Gotham Bridge in the lower reaches of the channel.

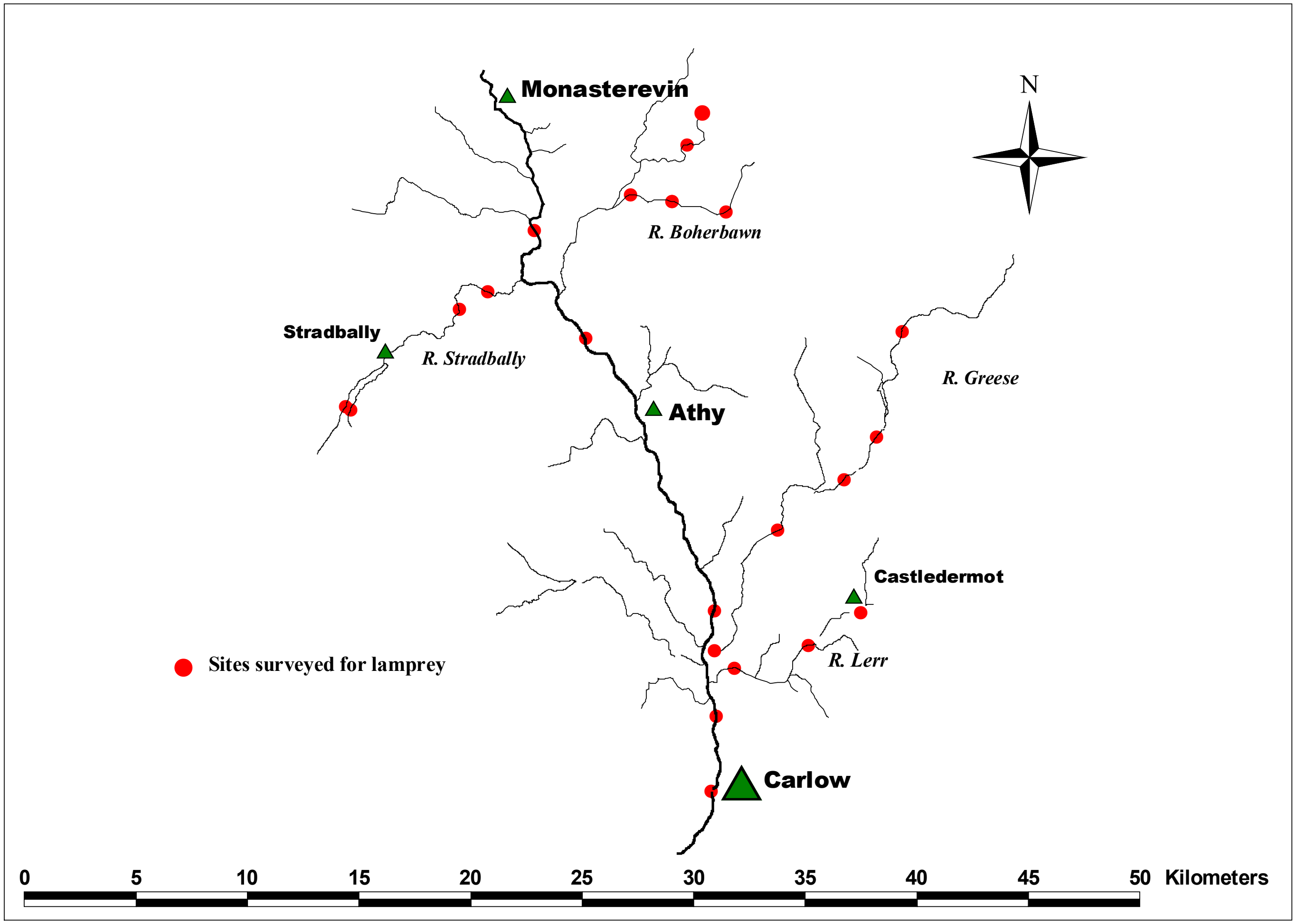



**Plate 4.3: Juvenile lamprey survey sites in the R. Barrow from Monasterevin to Carlow, 2004.**

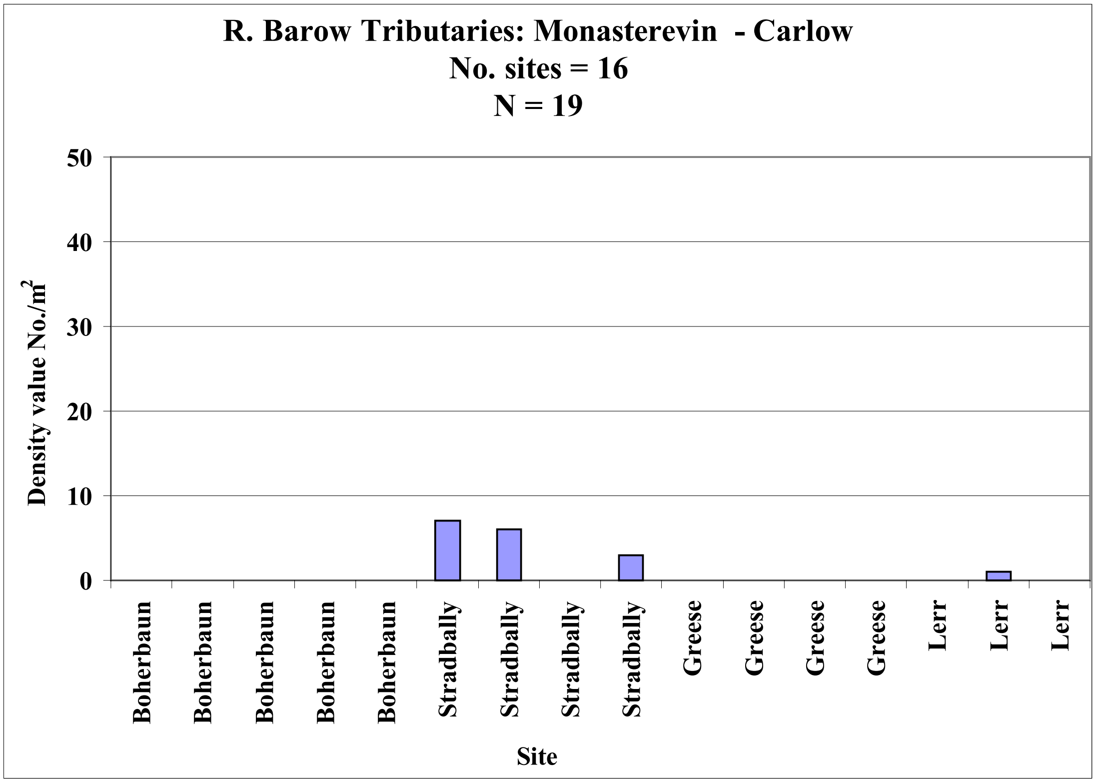



**Figure 4.6 Juvenile lamprey density in R. Barrow tributaries:Monasterevin - Carlow**

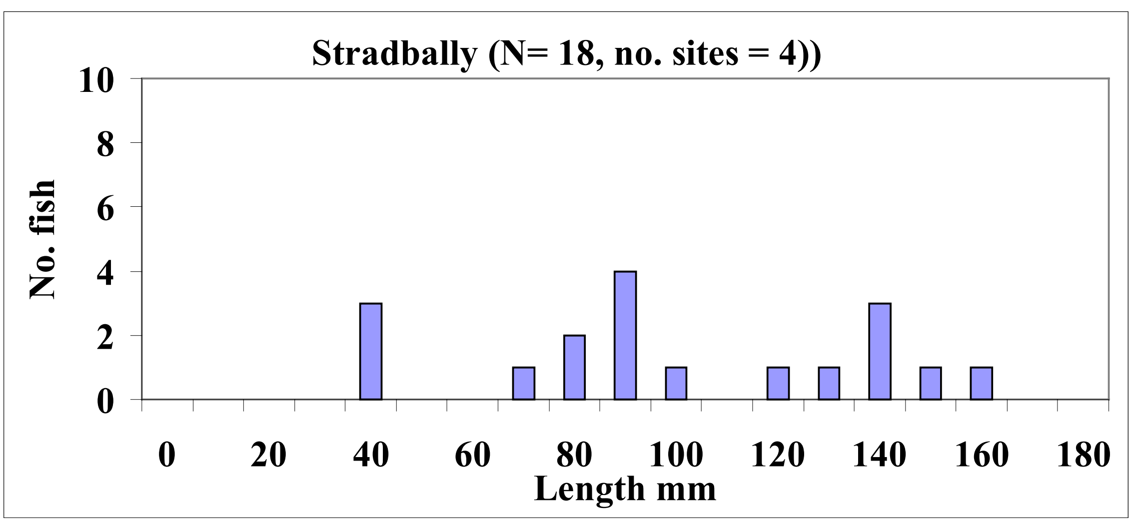
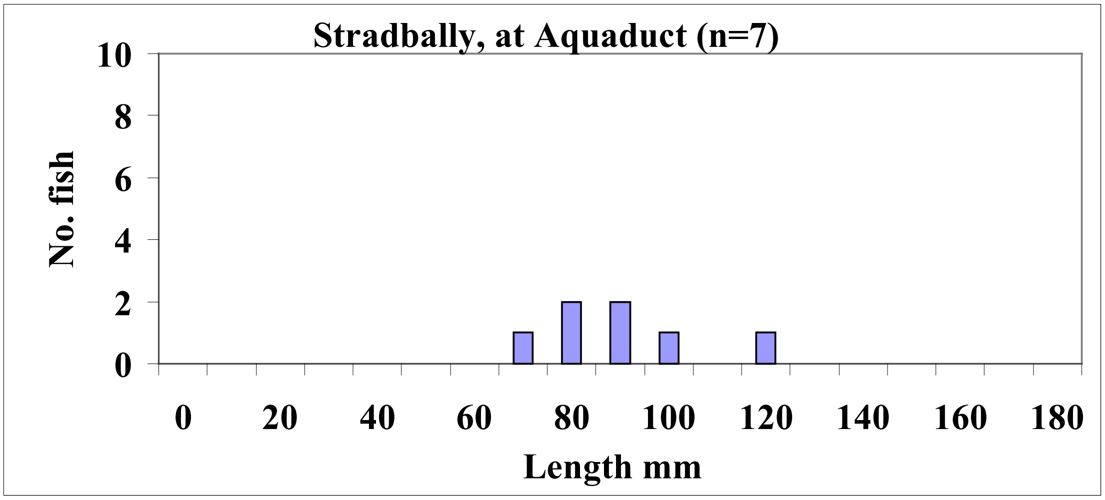
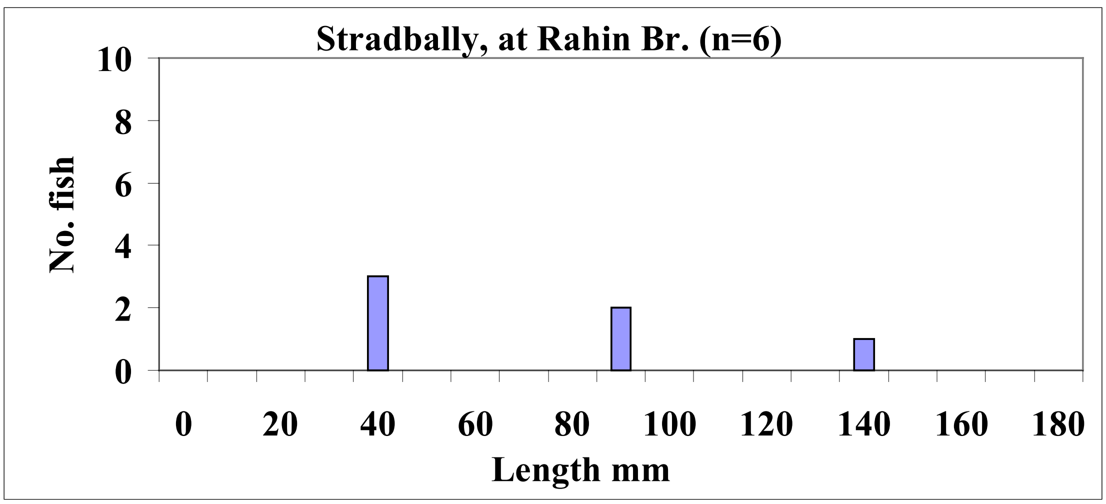



**Fig 4.7 R. Stradbally: Length frequency of lamprey ammocoetes**



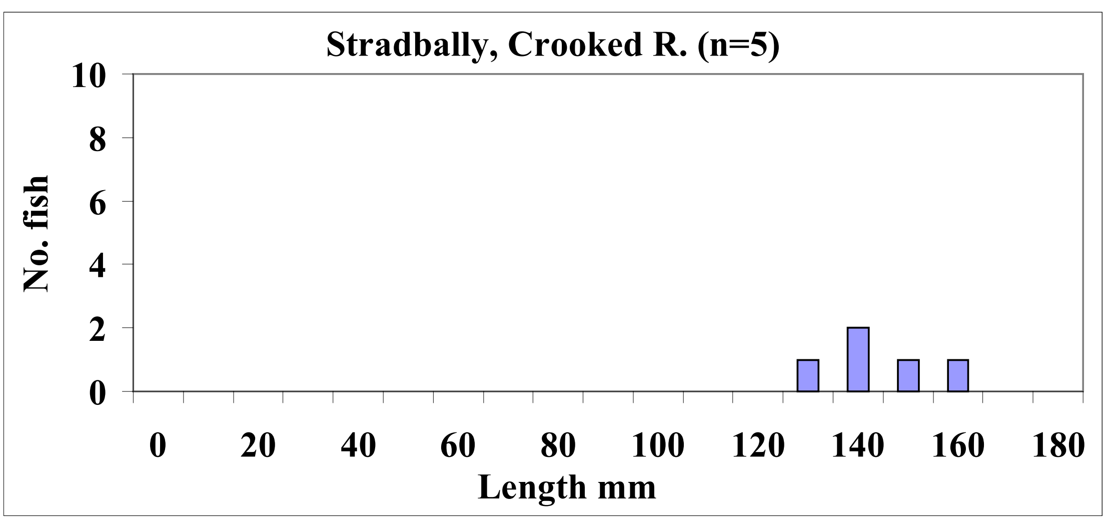




**Figure 4.7. R. Stradbally contd……………**

### 4.2.4 Tributaries discharging between Carlow and St. Mullins

This zone contained a greater number of SAC-designated tributaries than other zones and also yielded a relatively large number of juvenile lamprey. An overview (Fig. 4.8) indicated a wide density distribution, with some channels not registering any lamprey ammocoetes. However, three channels contained juvenile lamprey densities > 50 fish / $m^2$: the Duiske, the Fuseogue and the Mountain River. Of significance was the series of sites in the Black River, a non-SAC designated tributary in the Mountain system (Fig. 4.8).

***R. Burren:*** One site was quantitatively fished in this non-SAC channel but no juvenile lamprey was encountered. This contrasted with the results from Phase I when two sites, neither of which was used in Phase II, yielded minimum density data in the range 4 –5 fish/$m^2$.

***R. Fusheoge:*** Three enclosures were fished in this channel. The combined samples represented a number of age groups, with fish ranging in size from 10 mm to 160 mm. The presence of samples of length 10 mm and of modal length 40 mm points to the presence of both 0-group and 1- year old ammocoetes (Fig. 4.9). This channel also presented modal peaks at 90 mm and 130 mm. The density data (Fig. 4.8) indicated a very clumped distribution of ammocoetes in this system, with two zero values, of three sites surveyed, and one site with 66 fish/$m^2$. A small sample of sea lamprey, *Petromyzon*, was taken in this channel.

***Old Leighlin Stream:*** Two sites were fished on this narrow, relatively high-gradient channel. One site yielded a negative result. The population structure in the other site indicated the presence of three age groups, all of *Lampetra* (Fig 4.10).

***R. Acore:*** A small number of juvenile lamprey were taken in this channel. However, the combined length frequency data for the series of sites surveyed indicated a range of age classes, including fish of the 0-group and 1-year old group. The three sites surveyed had a density range of 5 – 9 fish/$m^2$ (Fig. 4.8), indicative of a more uniform distribution of ammocoetes in this channel than in the R. Fusheoge (above). The population structure, while disparate, did indicate the presence of at least three age groups including evidence of spawning in 2004 and in 2003 (Fig. 4.11). A small sample of sea lamprey, *Petromyzon*, was taken in this channel.

***Mountain River catchment:*** This large catchment may be broken into three segments. Two of these, the Aughnabriskey and the Mountain, are designated within the SAC while the third sub-catchment, the Dinin or Black River, has not been designated. The Aughnabriskey rises on the Blackstairs Mountains and has a very upland character whereas the Mountain channel is a more lowland extension. The Black River is a large sub-catchment of the Mountain system, joining the Mountain River in Borris, near the Barrow. The topography in the Black River system is more lowland with no areas of high ground or steep gradients. Sites in all three sub-catchments were quantitatively fished. The catchment as a whole yielded a large sample of ammocoetes, ranging in size from 30 mm to 140 mm. The length frequency distribution indicated a substantial sample in the 60 – 100 mm range. It is considered that this represents more than a single age group.

All sites fished on the Mountain channel main stem yielded juvenile lamprey. Some, such as those at and downstream of Borris, had similar structure with a predominance of fish in the 90 – 110 mm size range. The site upstream of Rosdillig Bridge displayed two age groups with modal peaks at 60 – 70 mm and 110 – 130 mm. The Black River also yielded ammocoetes at all sites. The overview for this channel indicated a wide range of sizes, with three clear modal groups (Fig. 4.12). These included one group of ammocoetes at 20 – 30 mm. No lamprey were taken in the site surveyed on the Aughnabriskey branch.

***Ballymurphy Stream:*** Three sites were fished in this system. The two sites in the vicinity of Ballymurphy both showed high juvenile density while the third site, near the confluence with the Barrow at Clashganny, did not produce any lamprey. Juvenile lamprey ranged in size from 20 – 120 mm with a predominance of fish of 50 – 90 mm. A small number of fish in the 20 –30 mm size range were also captured (Fig. 4.13).

***Duiske Stream:*** This channel is formed by the confluence of a series of small streams discharging from high ground, including Brandon Hill (570 m), around Graiguenamanagh. The channel discharges to the R. Barrow at the downstream side of a major weir on the main channel. The three sites examined in this channel were all in areas of glide, or moderated flow, with moderate to substantial accumulations of fine-grained sediment. All three sites yielded substantial numbers of juvenile lamprey. Density ranged from 14 – 60 fish/$m^2$ (Fig. 4.8). The length frequency distribution indicated a substantial number of ammocoetes in the 50 – 100 mm size range. It is considered that this grouping was composed of at least two age groups with modal lengths of 50 mm and one of 80 mm (Fig. 4.14).

The most upstream site, at Coolroe Ford, was almost exclusively composed of fish in the 70 – 100 mm size range. In contrast, the site at Well St. Quay, at the back of the main street in Graiguenamanagh, contained at least three age groups including young-of-the-year fish of 10 – 20 mm, a cluster with a modal peak at 50 mm and some larger fish in the 80 – 100 mm size range. A single juvenile sea lamprey was recorded here. The third site, a short distance upstream of the confluence with the R. Barrow, contained a small population relative to the two other sites. Nevertheless, two age groups were apparent.

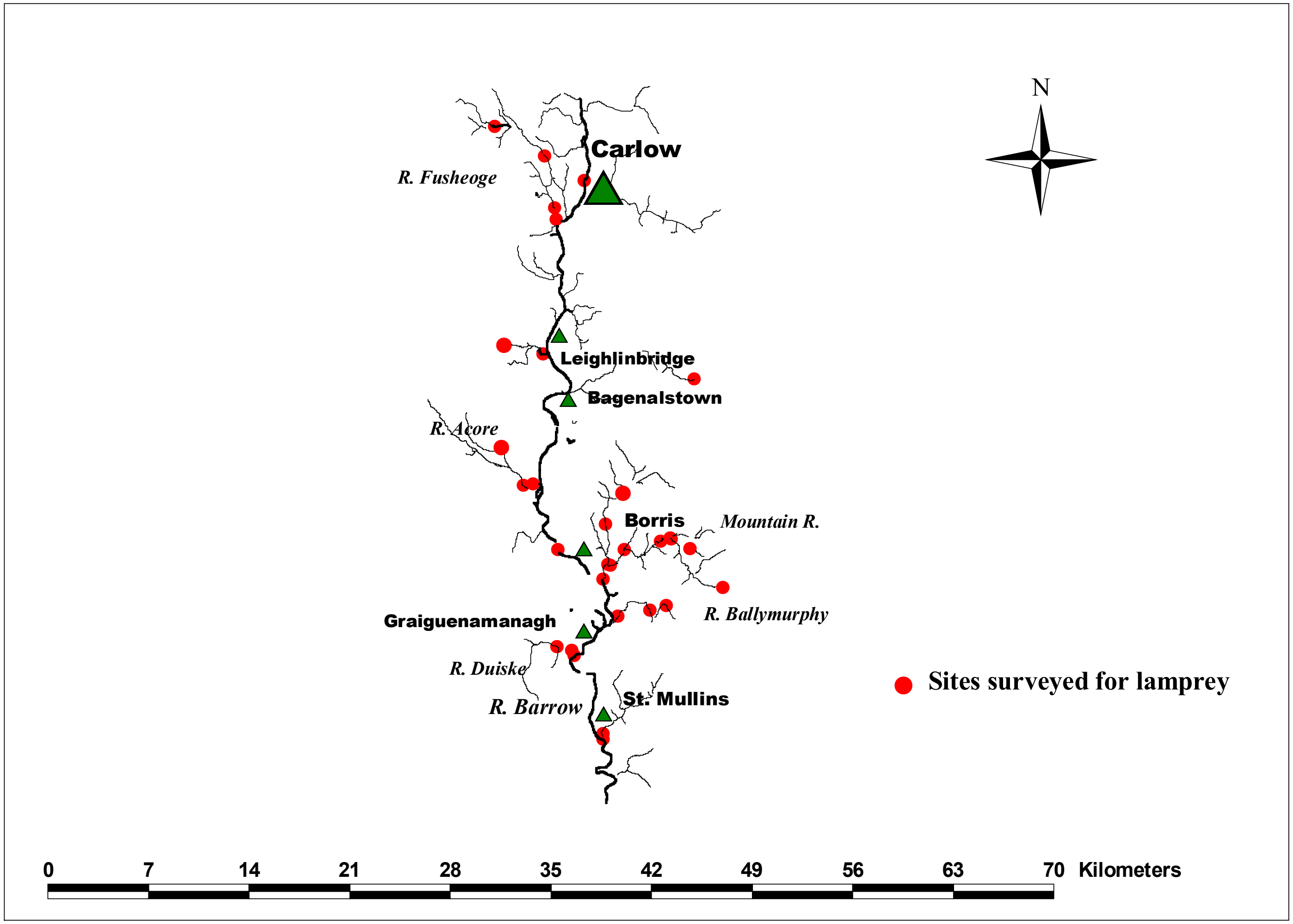



**Plate 4.4: Juvenile lamprey survey sites in the R. Barrow from Carlow to St. Mullins, 2004.**

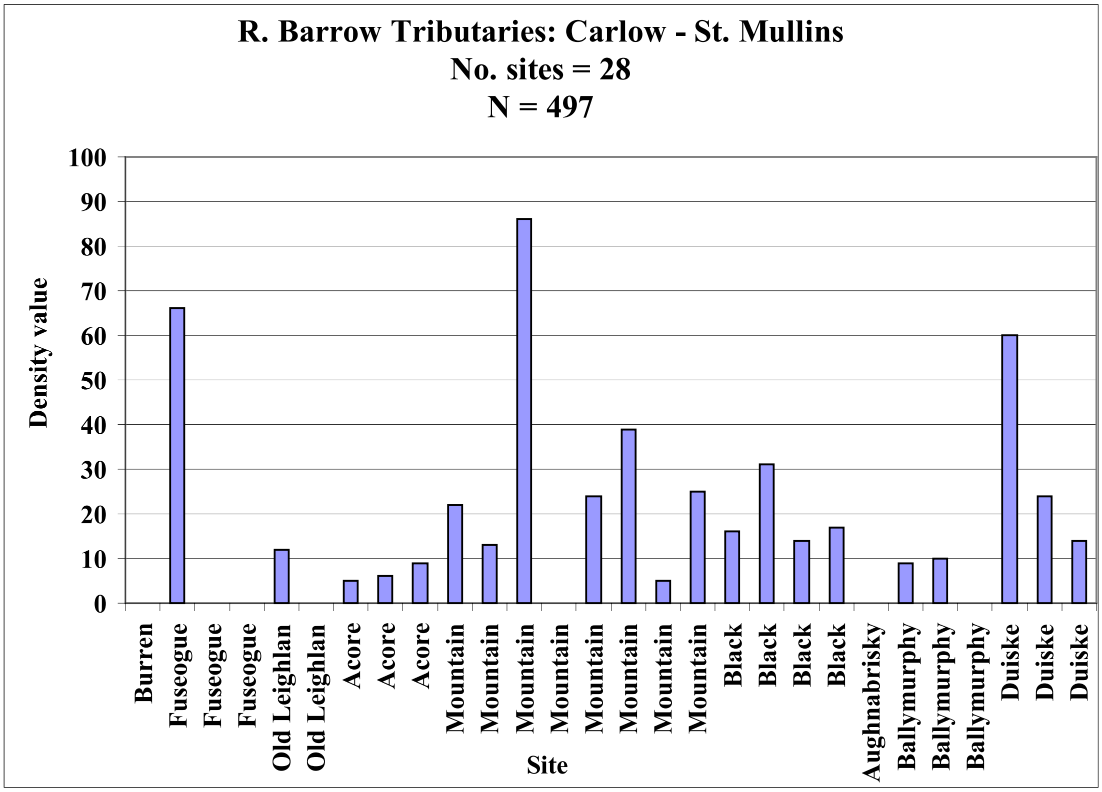



**Figure 4.8 Juvenile lamprey density in R. Barrow tributaries: Carlow - St. Mullins**

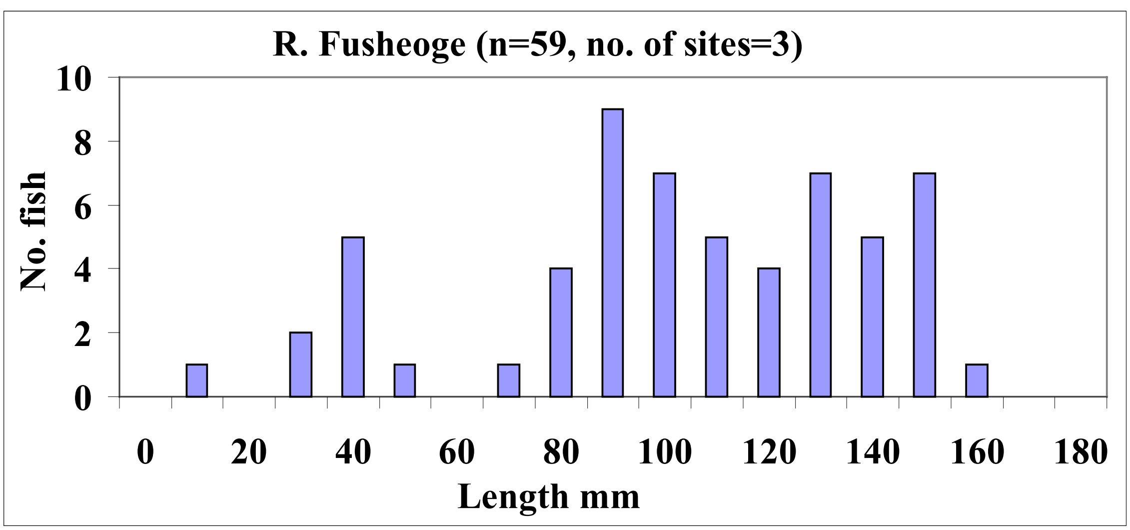



**Fig 4.9 R. Fusheoge: Length frequency of lamprey ammocoetes**

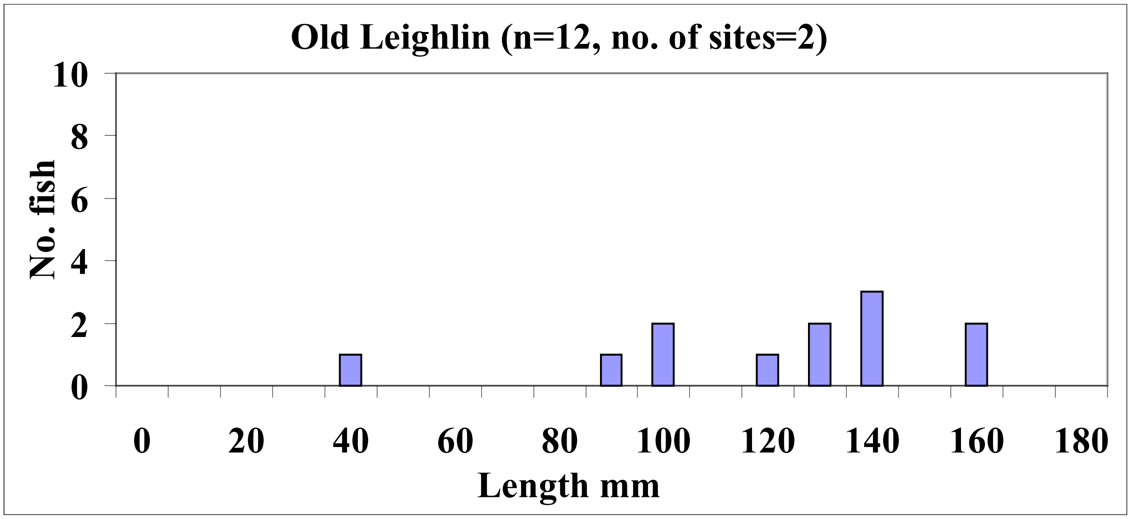



**Fig 4.10 Old Leighlin Stream: Length frequency of lamprey ammocoetes**

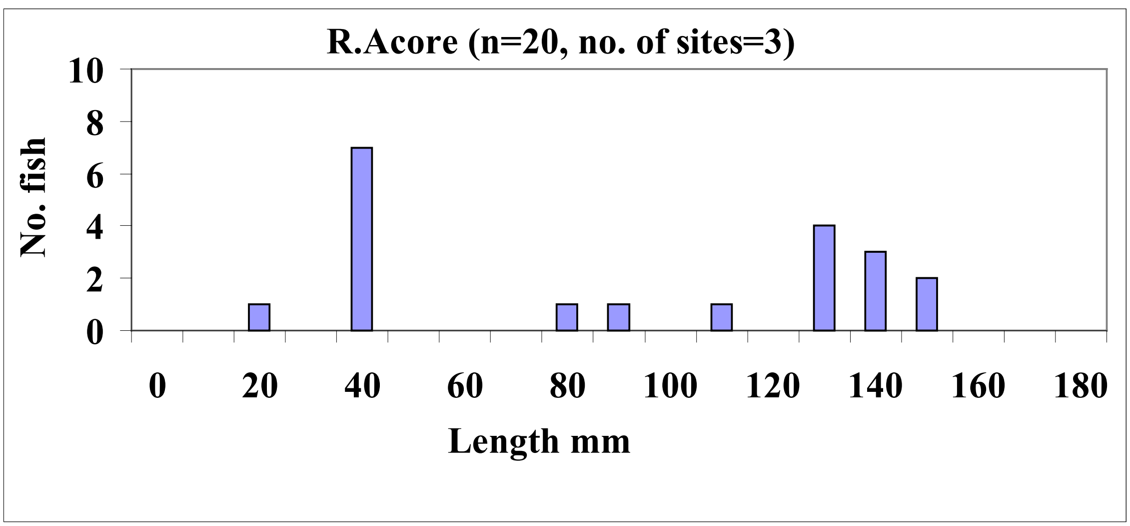
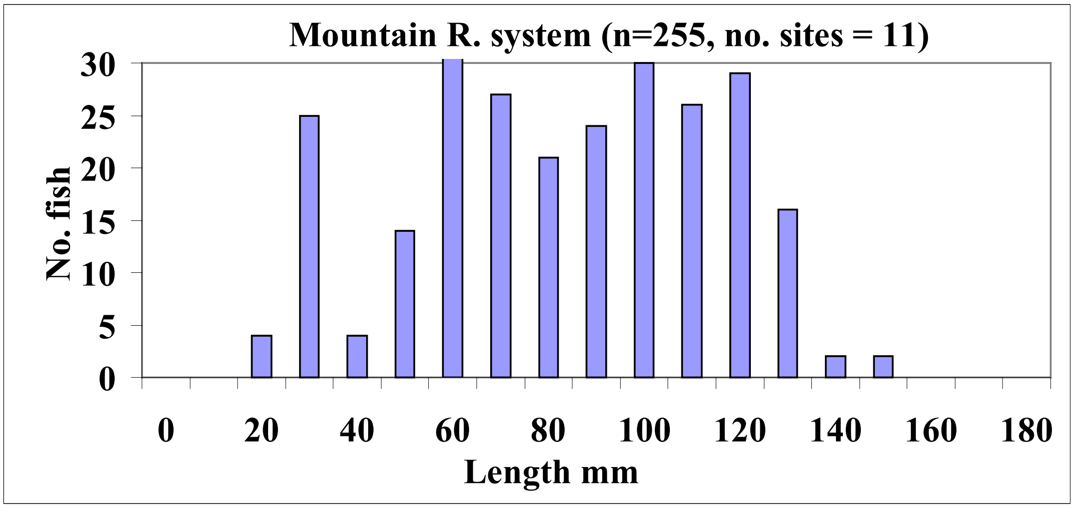
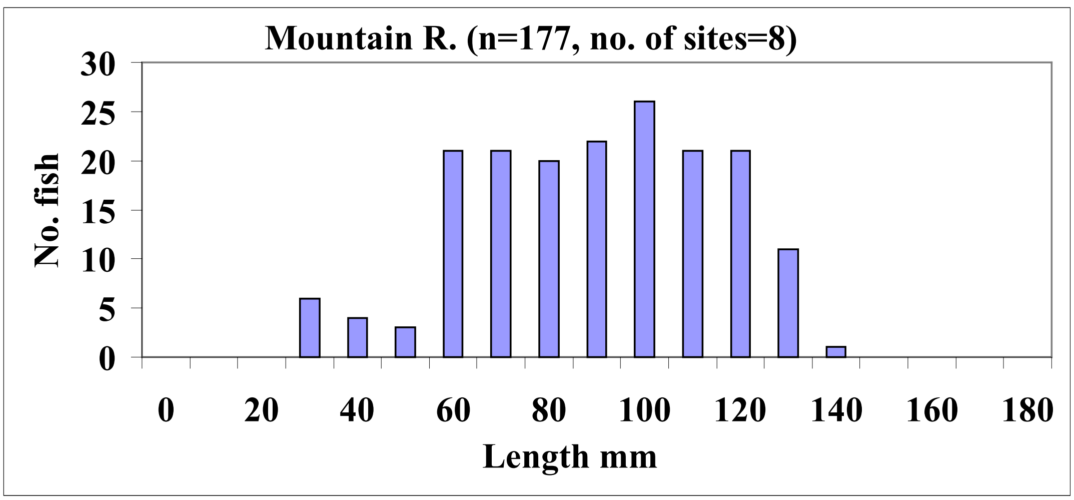



**Fig 4.11 R. Acore: Length frequency of lamprey ammocoetes**



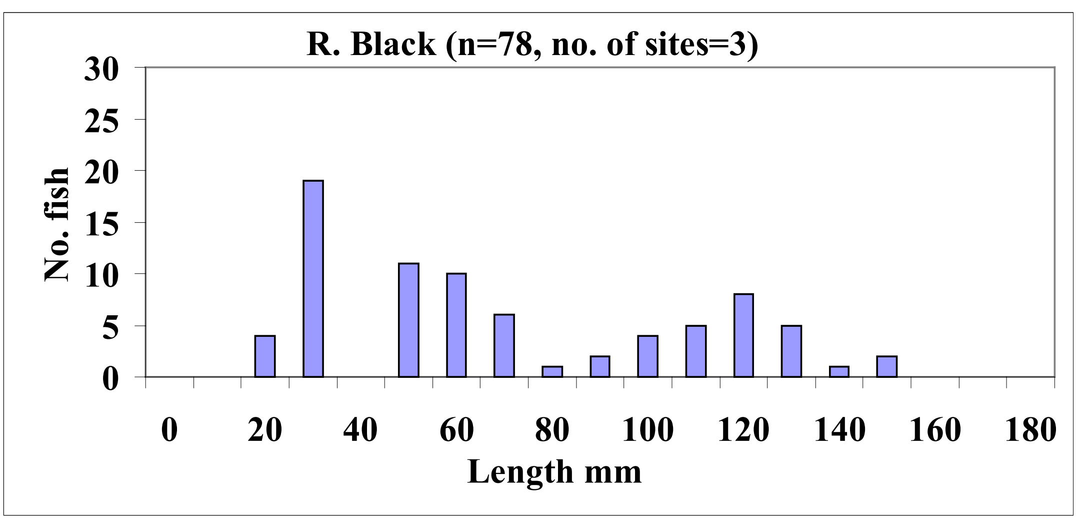
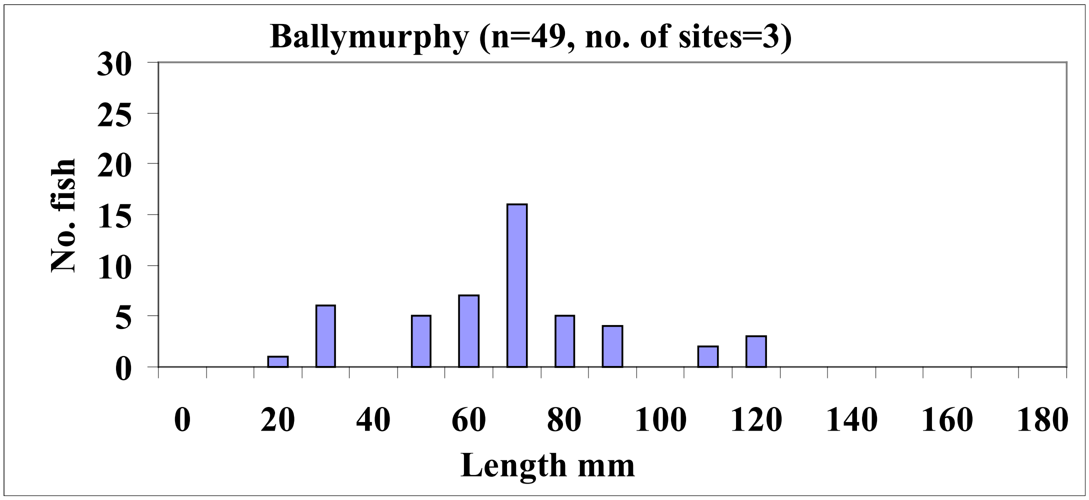
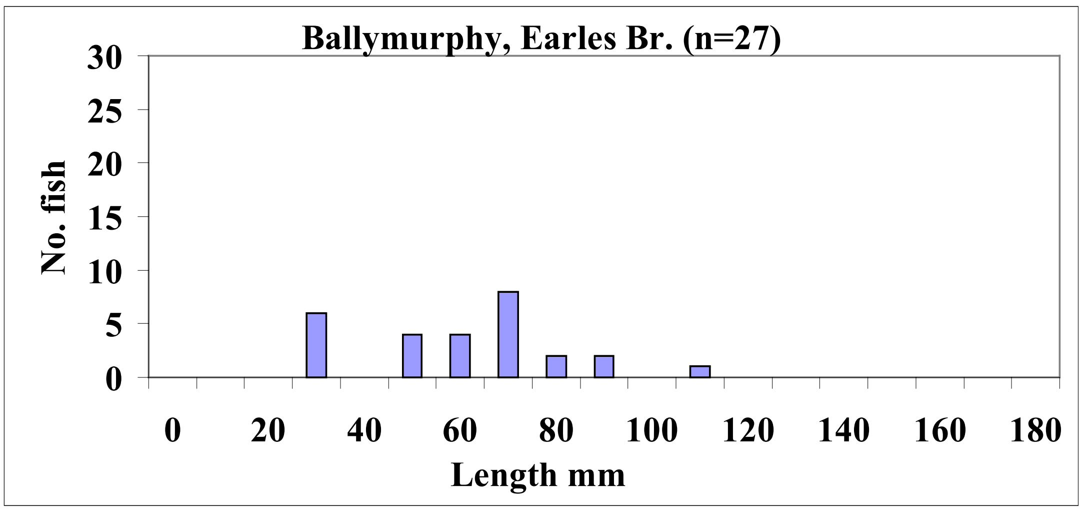




**Fig 4.12 Mountain R. system: Length frequency of lamprey ammocoetes**



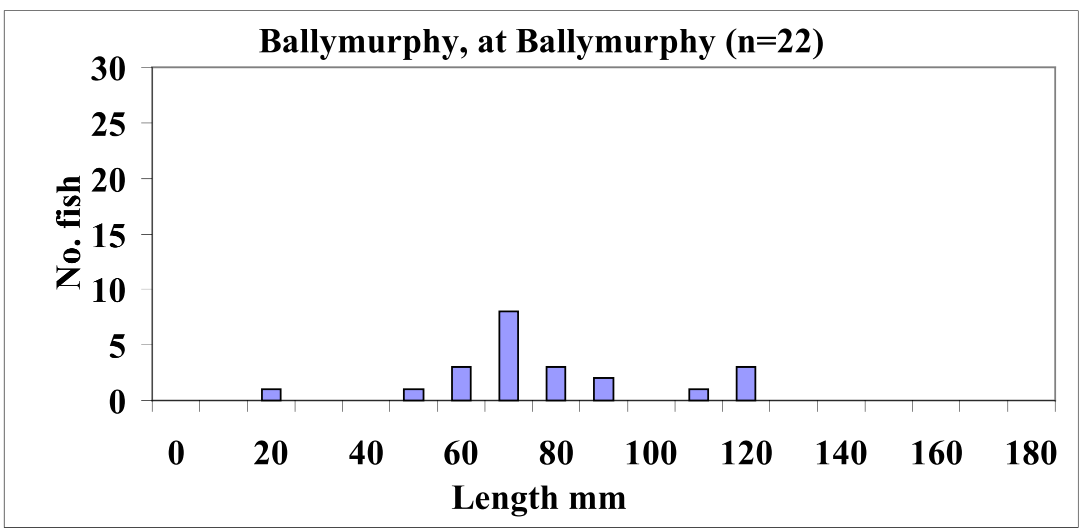




**Fig 4.13 Ballymurphy River: Length frequency of lamprey ammocoetes**

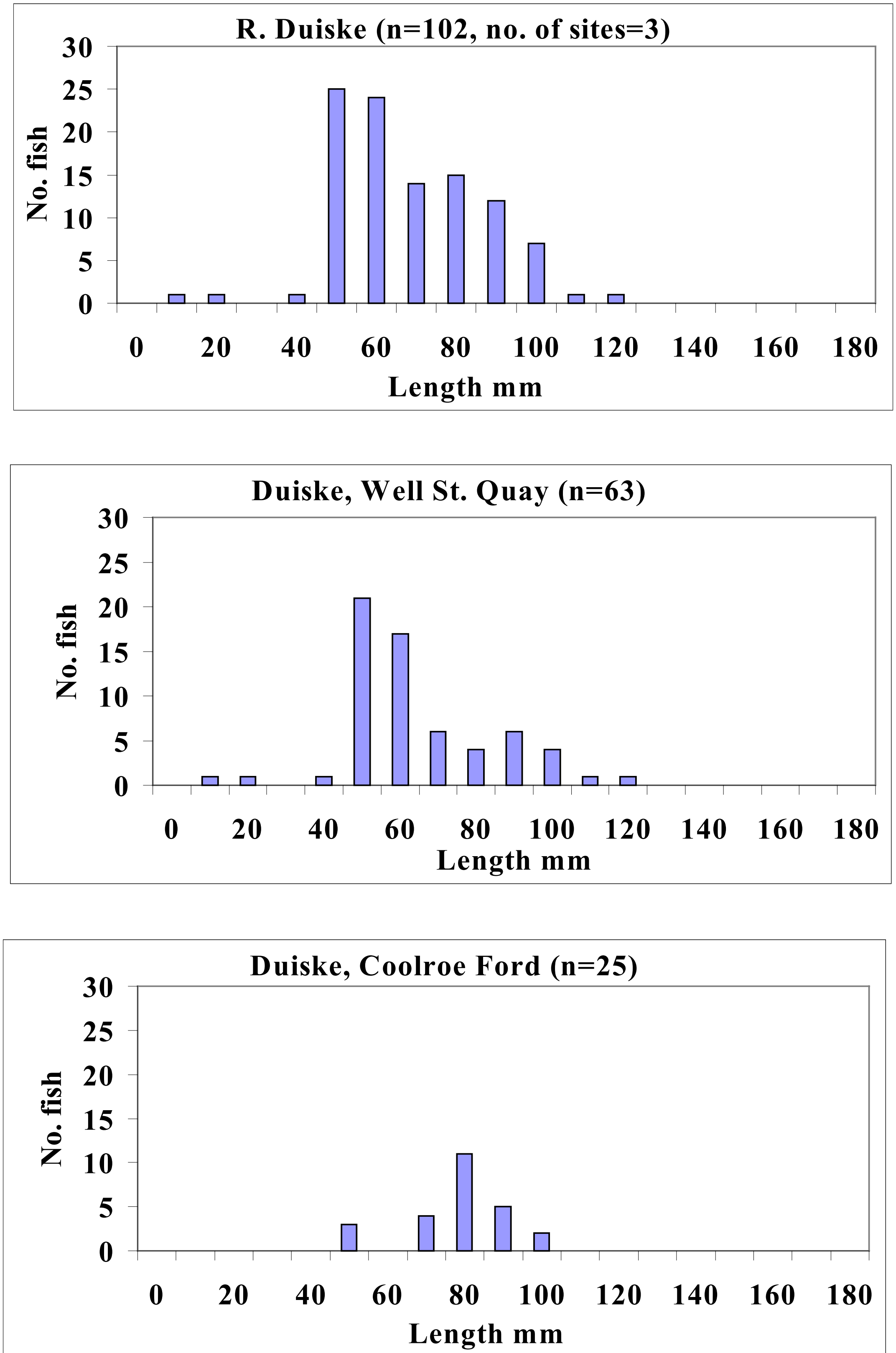



**Fig 4.14 Duiske River: Length frequency of lamprey ammocoetes**

### 4.2.5 Tributaries discharging to tidal R. Barrow

***Aughavaud River:*** This channel has its origins on high ground in the Blackstairs Mountains and descends through a deeply incised valley in its middle and lower reaches. The bed is characterised by large boulders and cobble, with deposits of coarse sands. No areas of fine-grained deposition were observed. Several patches were surveyed in the Phase I operation, yielding no ammocoetes. The single enclosure fished quantitatively in Phase II did not produce any juvenile lamprey (Fig. 4.15).

***Pollmounty Stream:*** As with the Aughavaud Stream (above) this small channel in the lower reaches of the catchment had a bed composition dominated by large stony material. Potential depositing areas were limited by channel gradient. The available areas of deposition contained a coarse-grained sand matrix. Following the findings from the Phase I survey, a single enclosure was fished, immediately downstream of a water abstraction weir that would impede upstream passage of migrating adult lamprey. Despite the physical habitat, the channel did yield some juvenile lamprey, principally in the length range 40 – 100 mm. This cluster is considered to have contained at least two age groups. An isolated fish of 140 mm was also taken (Fig. 4.16). No juvenile sea lamprey were taken, despite the fact that the channel discharges directly to the estuary of the Barrow and the fact that bed material was not inappropriate for sea lamprey spawning.

***Maudlins Stream:*** The composite sample from the two sites fished in this channel ranged in size from 30 mm to 110 mm and pointed to three age groups with modal values at 30 mm, 60 – 70 mm and 90 mm (Fig. 4.17). The site at the Ponds was dominated by fish in the 50 – 100 mm range with two modal groups of 50 – 70 mm and 80 – 100 mm. In contrast, the site at Kehoe's Poultry Farm consisted largely of younger fish of 30 – 40 mm, along with small numbers of larger fish.

***Glenmore Stream:***

Access to this channel proved very difficult, with only one site viewed in the Phase I study. Quantitative sampling took place at a single enclosure and this site yielded a large sample of ammocoetes, ranging in length from 20 mm to 110 mm. The length frequency indicated the presence of at least three age classes (Fig. 4.18).

***Campile Stream:*** One site, only, was surveyed here and it yielded a small number of ammocoetes. The sample indicated the presence of three age groups, with a modal peak at 90 mm (Fig. 4.19).

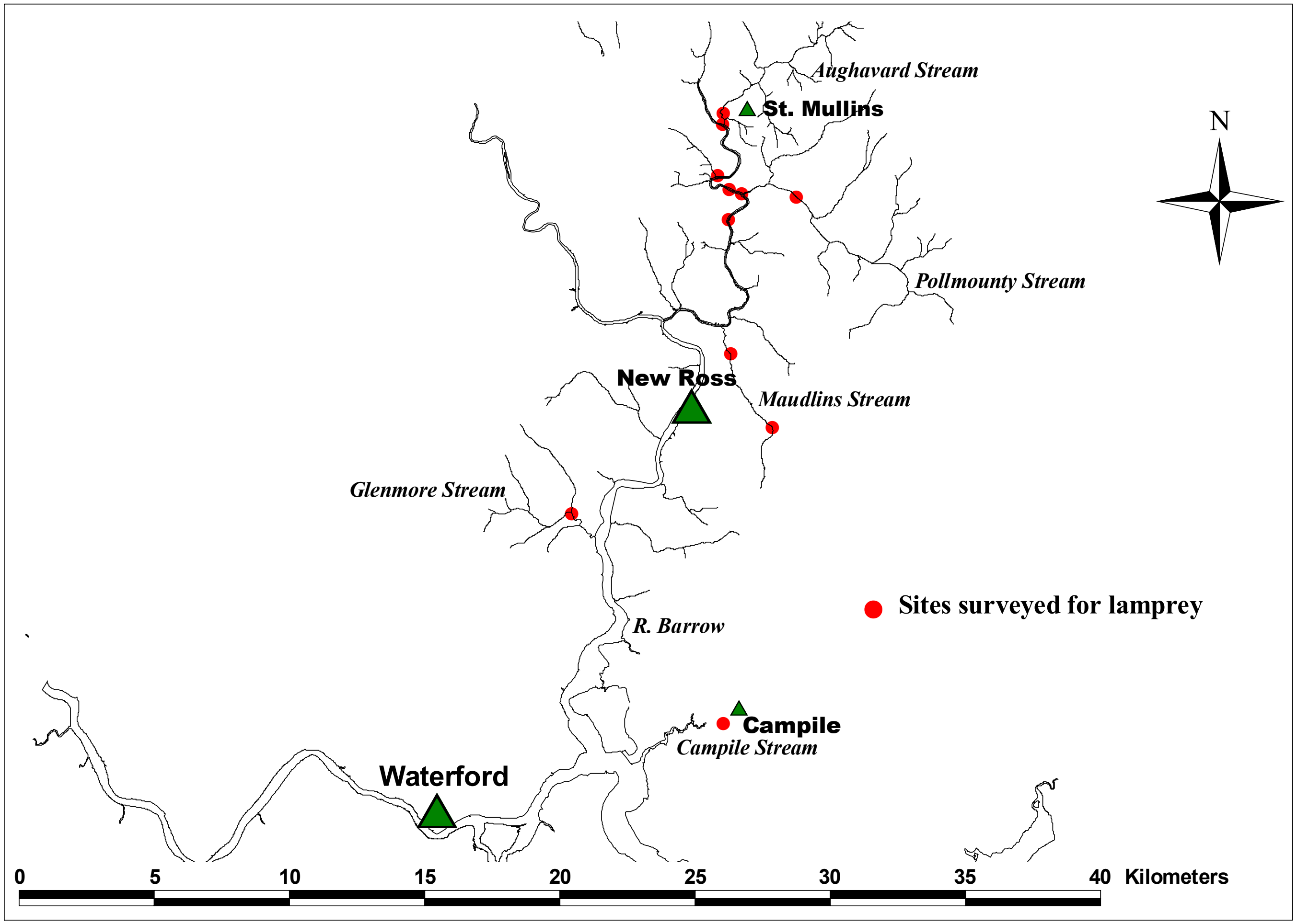



**Plate 4.5: Juvenile lamprey survey sites in the R. Barrow from St. Mullins to Campile, 2004**

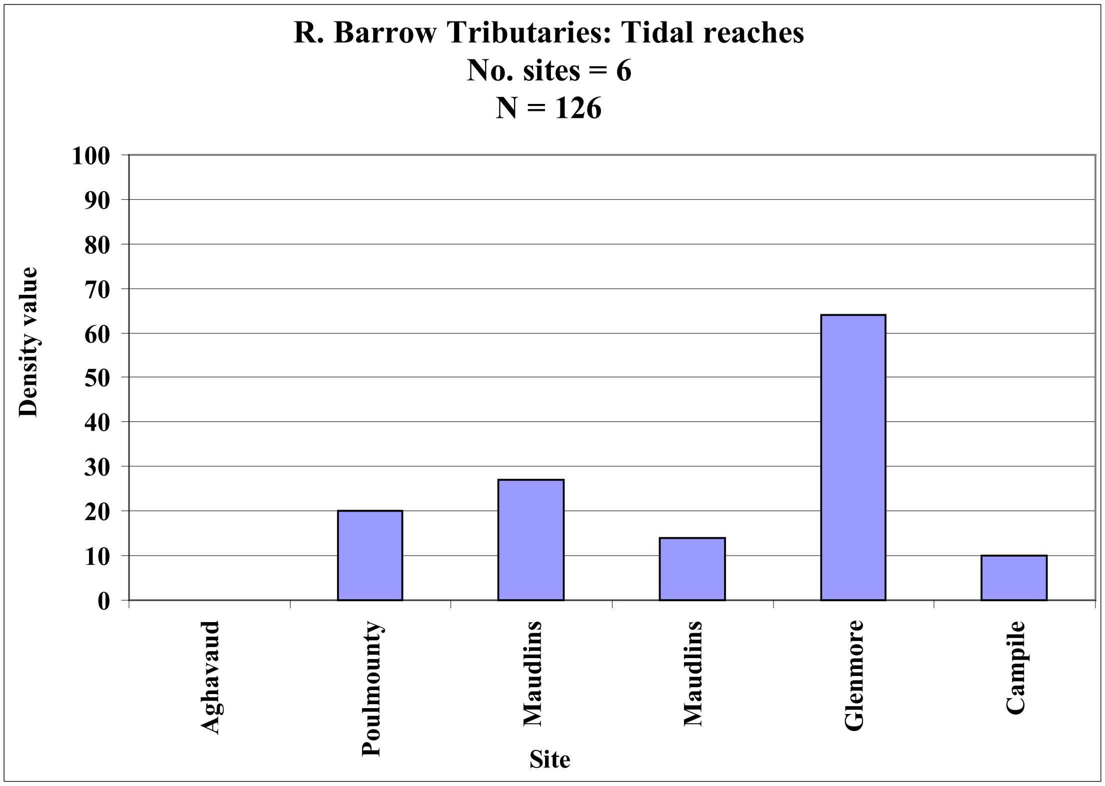



**Figure 4.15 Juvenile lamprey density in R. Barrow tributaries: Tidal reaches**

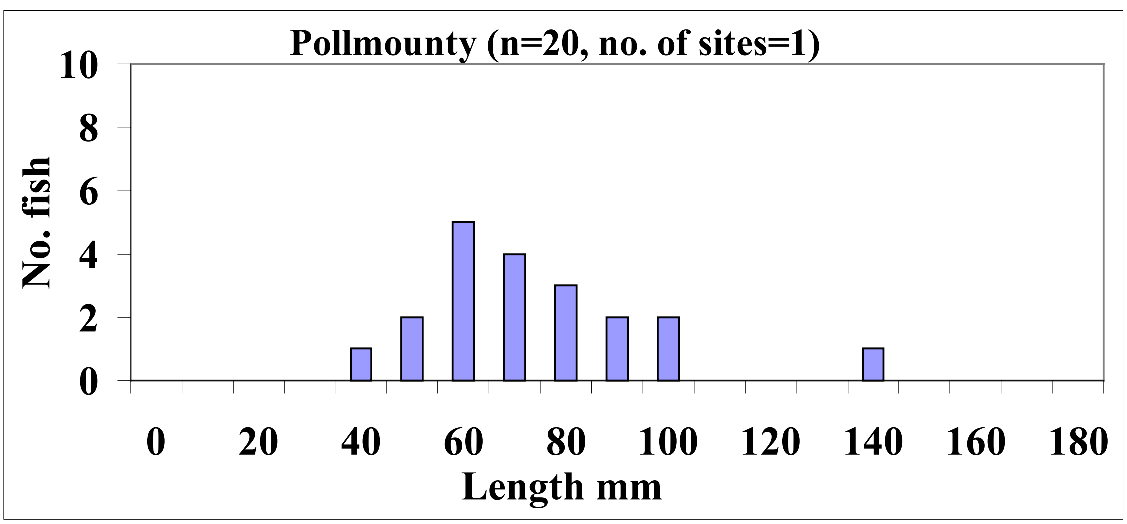
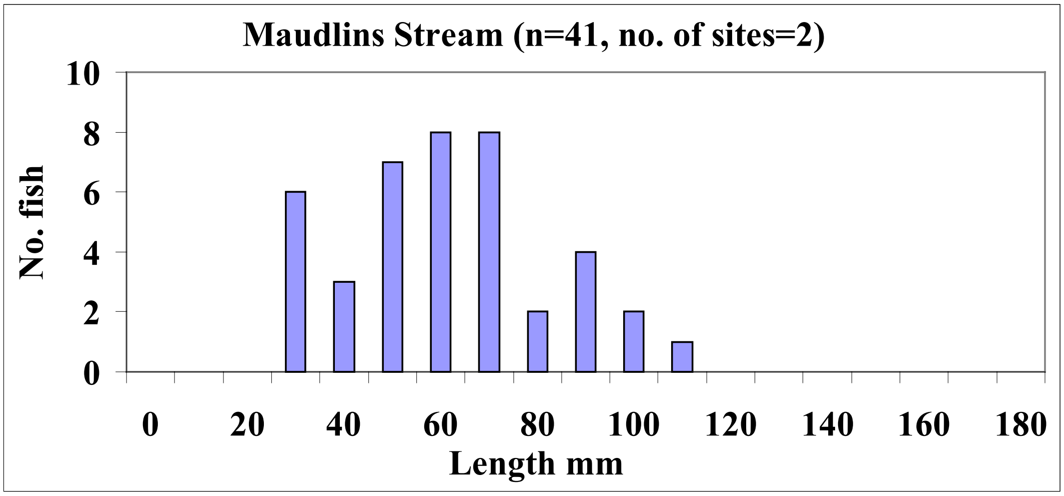
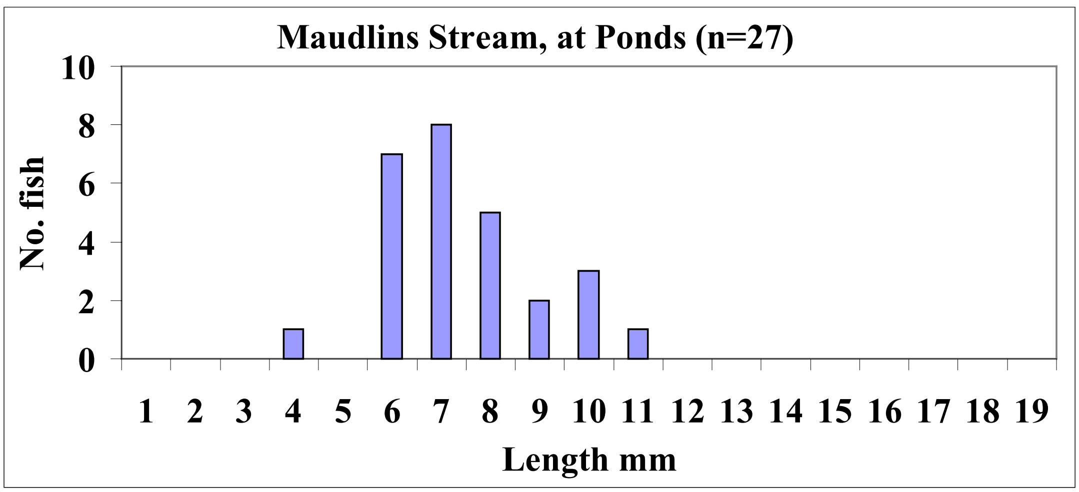



**Fig 4.16 R. Pollmounty: Length frequency of lamprey ammocoetes**



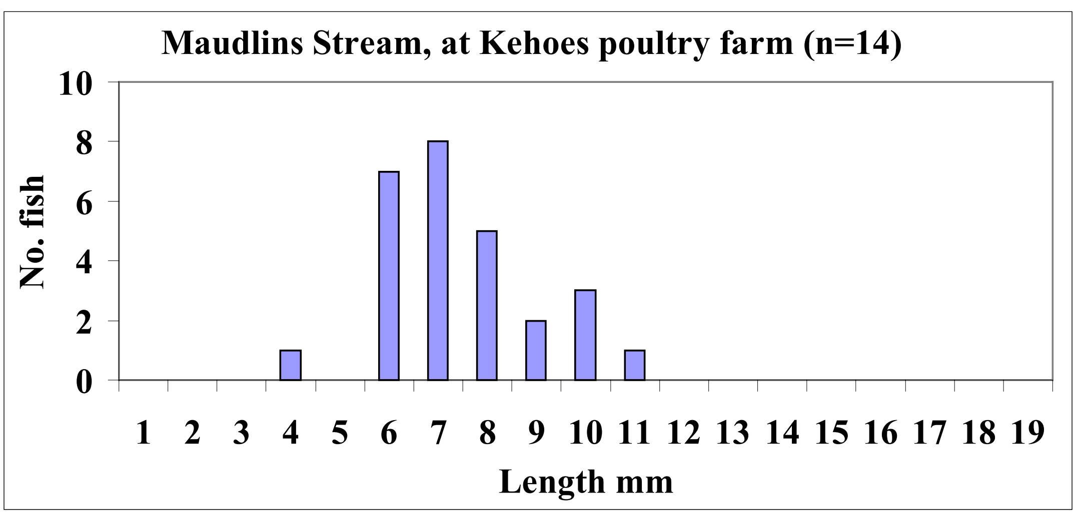




**Fig 4.17 Maudlins Stream (New Ross): Length frequency of lamprey ammocoetes**

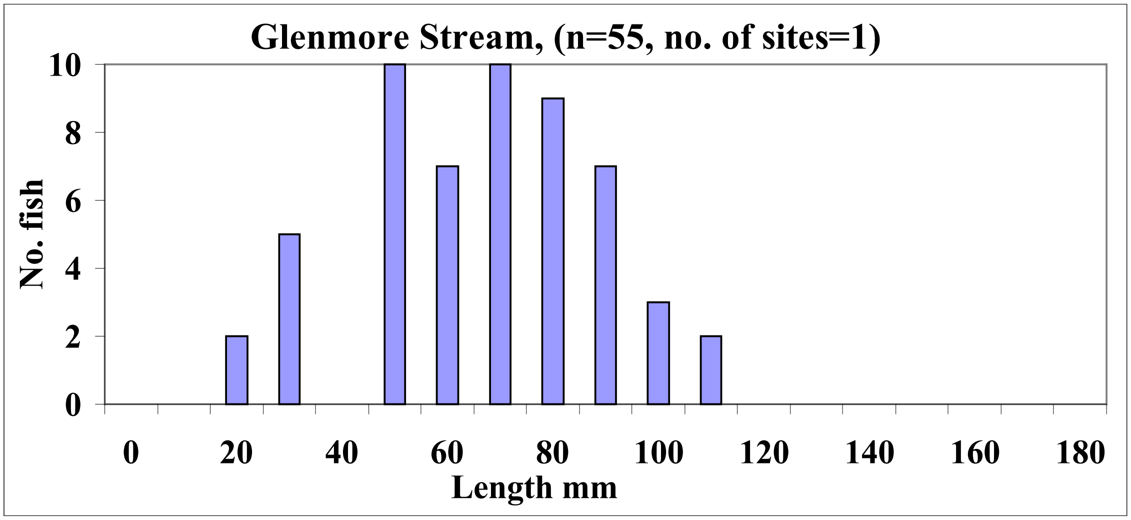



**Fig 4.18 Glenmore Stream: Length frequency of lamprey ammocoetes**

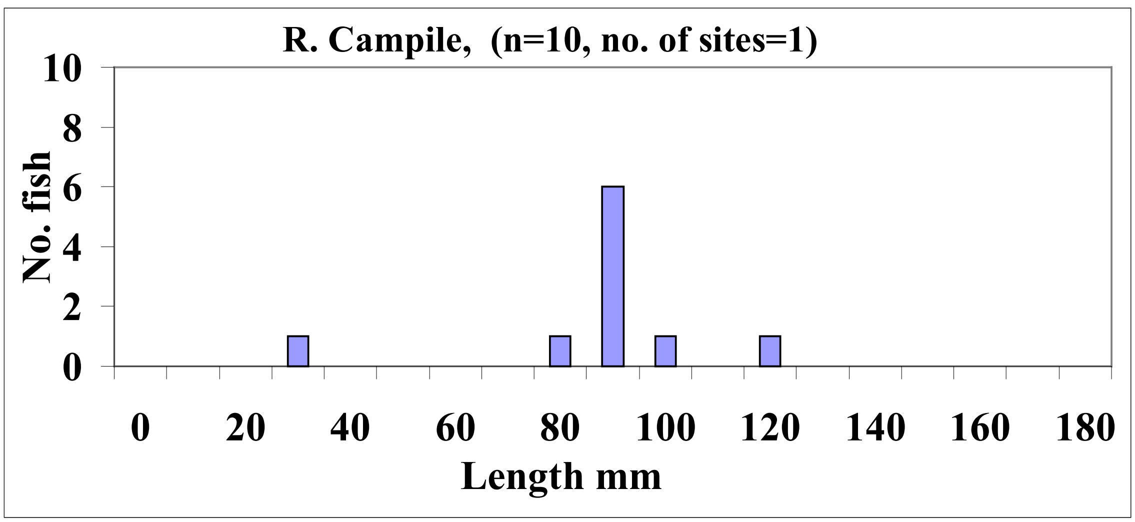



**Fig 4.19 Campile Stream: Length frequency of lamprey ammocoetes**

**4.2.6 Status of sea lamprey (*Petromyzon marinus* L.)**

Samples of sea lamprey were very rare, being taken in only four of the channels surveyed. In all cases numbers taken were very small, consisting of individual specimens in two cases and of two and four individuals respectively in the other two cases. One of the channels, the Maudlins channel, discharges directly into the tidal reaches of the Barrow while the Duiske channel discharges immediately downstream of the large weir in Graiguenamanagh. The sites on the Acore and Fusheoge lay in the lower reaches of each of the two channels.

The sample of sea lamprey was insufficient to give an indication of the population structure of juveniles of this species in the Barrow system. However, the data did indicate a range of age classes (Fig. 4. 18). No young-of-the-year fish were captured and the fragmented nature of the length frequency data indicated that successful spawning might be very intermittent.

The presence of juvenile sea lamprey in the Acore and Fusheoge indicated that adult sea lamprey can navigate or circumvent the major weirs on the main stem of the Barrow (Table 4.3).

**Table 4.3 Penetration of anadromous sea lamprey into R. Barrow catchme based on capture of sea lamprey ammocoetes in 2004.**

| Name of channel | Distance u/s of tidal limit at St. Mullins (km) |
|---|---|
| R. Maudlins | -9.6 |
| R. Duiske | 5.8 |
| R. Acore | 20 |
| R. Fusheoge | 43 |

In the course of the Phase II surveying in the Barrow main stem, areas at the downstream side of some of the major weirs were examined from a boat for evidence of use by spawning sea lamprey. No such evidence was apparent.

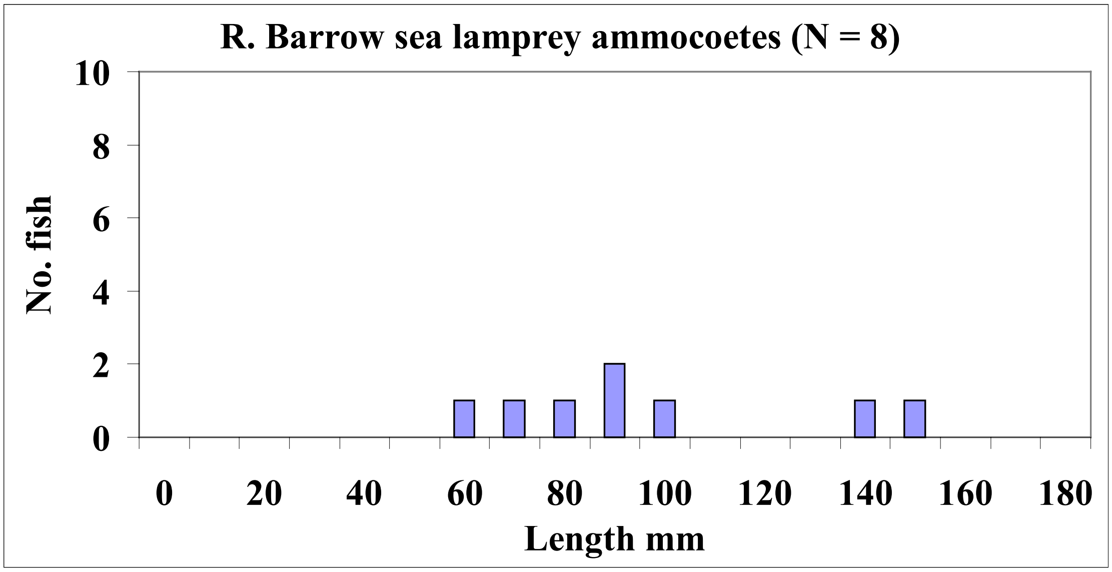



**Figure 4.20 R. Barrow: Length frequency of sea lamprey ammocoetes in catchment**

### 4.2.7 Analysis of Habitat attributes collected

Information collected on-site during the Phase II study, in addition to the subsequent sediment analysis carried out, was pooled into a larger national study examining juvenile lamprey density and distribution (King and Lehane 2005). Principal Components Analysis (PCA) was conducted on the environmental data because of the likely inter-correlation between some of the environmental variables measured. Fine-grained substrate was the dominant factor in the first component (PC1).

The results of the Principal Component Analysis were used as independent variables in stepwise multiple regression analysis where lamprey density (log transformed) was the dependent variable. Within the Barrow catchment, the findings indicated that lamprey densities were inversely related to sediment size. The results also suggest that lamprey density in the River Barrow was negatively related to % overhead cover.

# 5. Discussion

## 5.1 Status of *Lampetra* in the Barrow Catchment

The majority of ammocoetes found in the present study were allocated to the genus *Lampetra*, following Gardiner (2003), with low numbers of *Petromyzon* ammocoetes recorded. This predominance of *Lampetra* is consistent with findings from other studies (Gardiner *et al.* 1995, Gardiner and Stewart 1997, APEM 2004 a and b, King and Linnane 2004, O' Connor 2004). The inability to distinguish ammocoetes of river- and brook lamprey renders it impossible to determine the relative contribution of each species to the ammocoete populations encountered. It is thus not possible to ascertain, through ammocoetes, the extent of anadromy of river lamprey in the Barrow catchment. It is known from netting surveys that river lamprey occur in the upper tidal Barrow in the spring (CFB unpublished data). However, the degree of upriver penetration and the size of population involved is not known.

To answer these questions it would be necessary to undertake two separate operations. In the first instance, it would be necessary to undertake sampling (via electric fishing or trapping with fyke nets) for upstream migrants within individual channels. This would confirm whether or not river lamprey adults were moving into specific channels. It would also indicate the timing of such movement, size range of individuals and number of individuals involved. The second operation would involve walking channels to observe spawning activity in progress. This would permit a pin-pointing of specific spawning sites and would also permit an enumeration of spawning populations.

River lamprey spawning redds are small relative to those of sea lamprey and not as easily observed. Recent walk-over surveys along tributaries of the Nore, Slaney and Munster Blackwater, have not identified river lamprey redds. In contrast, Jang and Lucas (2005) described an intensive spawning effort by river lamprey focussed into a relatively small and discrete gravelled area of channel in the UK, despite the presence of other, apparently similar, gravelled areas within this channel. An apparently similar focussing of river lamprey spawning effort into a single gravel shoal was observed and described by staff of the Eastern Regional Fisheries Board from the R. Slaney in

2002 (Joseph Morris, pers. comm.). If this focussing were a characteristic of river lamprey spawning then it would be imperative to find such locations and ensure their conservation.

Irrespective of species, the present study did not identify the presence of juvenile lamprey in a number of channels, despite sampling being carried out in locations with appropriate habitat attributes. The distribution of negative sites was not uniform among the tributaries, when grouped into the four geographic zones from headwater to tidal limit, as used in Chapter 4 above (Table 5.1). This Table identified a clear difference between channel groups above and below Carlow, with a substantial increase in the percentage of negative sites upstream of Carlow. The high incidence of negative sites is considered due to a paucity of suitable areas of fine sediment deposits. While all areas sampled were composed of such sediments, depositing areas were infrequent in many channels, such as the Lerr, Boherboy and Stradbally – all of which lie in the zone Monasterevin - Carlow.

**Table 5.1. Comparison of lamprey amocoete status in tributary channels**

| | No. sites fished | No. negative sites | % negative sites | Density range Min | Density range Max |
|---|---|---|---|---|---|
| **Source - Monasterevin** | 7 | 4 | 57.14 | 6 | 27 |
| **Monasterevin - Carlow** | 16 | 12 | 75.00 | 1 | 8 |
| **Carlow - St. Mullins** | 28 | 7 | 25.00 | 5 | 85 |
| **Tidal reaches** | 6 | 1 | 16.67 | 10 | 63 |

In others, suitable areas of deposition were confined to the lower reaches of channels, as in the case of the Old Leighlin, Acore and Fusheoge, all of which lie downstream of Carlow. It is likely that walkover surveys to determine extent of suitable ammocoete habitat, as described and used in selected Scottish channels (APEM 2004 a & b), would register very low percentage suitability in channel lengths in many of the Barrow tributaries examined in this study. It is considered that the topography of many of the channels may militate against presence of extensive habitat for ammocoetes. Many of the tributaries are short, relative to those in, for example, the

Slaney and many have a high gradient over much of their course, carrying down bed material of a diameter too large to permit burrowing. Thus many simply do not have the fluvial geomorphological capacity to generate sufficient quantities of fine sediments and permit their deposition to form an infrastructure capable of sustaining large ammocoete populations in a large number of locations.

It is evident that the findings from the Barrow point to a non-uniform distribution of lamprey ammocoetes. Density can vary substantially from one area of deposition to another within the same channel. Indeed, investigations by CFB (unpublished data) have clearly shown that density can vary between contiguous patches of sediment, of visual similarity, within the same sediment bank. Given that intra-site variation can be substantial, it is clear that inter-site variation, within the same channel, can also be expected to be substantial. This clumped or clustered distribution has clear implications for sampling, as well as for any monitoring programme. This issue is examined by King and Lehane (2005) as well as recent English (Harvey and Cowx 2003) and Scottish (APEM 2004 b) reports. Elliott (1977) has pointed out that the dispersion of a population may become close to random in the case of low population density. The degree and nature of clumping or aggregation will have an impact on quadrat size selected for sampling (Elliott 1977). Deployment of quadrat is another factor that requires consideration in the present case, where water depth and extensive encroachment of marginal vegetation prevented sampling – as on the main stem of the R. Barrow. The ability to deploy may also be hampered by a patchy distribution of suitable sediment. Harvey and Cowx (2003) lay out a procedure for estimation of number of sampling sites required in a river system to determine change, from one monitoring period to another. They advise "..as a rule of thumb, approximately 40 sites should be surveyed in UK river catchments to provide an acceptable level of precision of ammocoete abundance".

**5.2 Status of sea lamprey**

The sea lamprey has the ability to penetrate long distances into fresh water and this ability can be constrained by barriers in the channel. Weirs and dams constructed for navigation, as on the Barrow main stem, for hydroelectric schemes and for irrigation, frequently serve to restrict sea lamprey upstream migration or eliminate it from the catchment (Beamish 1980, Assis 1990, Nicola *et al.* 1996, Meyer and Brunken 1997). Sea lamprey adults migrate up into freshwater from the sea at a time when flow in rivers is frequently falling or at a low level. This is a major factor in impeding upstream passage of this species when it encounters physical obstructions to passage. The very limited distribution and small population size of sea lamprey in the Barrow system, as evidenced by the findings of the present study, mirror the findings from some, although not all, other recent Irish investigations. The sea lamprey, unlike the salmon, cannot jump. Individuals can negotiate certain types of fish pass and can also use their suctorial mouth to clamp onto the face of a slope and gradually 'suction-clamp' their way up the face of an obstruction, provided that the slope angle is relatively shallow. They are also reported to climb over one another, aggregated at the foot of weirs, in an attempt to overcome the obstruction (Igoe *et al.* 2004). In the case of the Barrow, sea lamprey may be able to avail of the opening and closing of the lock gates, present in association with every weir, that permit navigation to negotiate the obstructions. This view is supported by the occurrence of sea lamprey ammocoetes in the Fusheoge tributary, 43 km upstream of the upper tidal limit at St. Mullins.

Investigations on the Suir and Nore, the sister rivers of the Barrow, have shown both these channels to have extensive gravelled areas on the bed of the channel in open flowing water. Both systems have numerous weirs, like the Barrow, but they have not been developed for navigation in their freshwater reaches and neither has navigation passage to circumvent the weirs. In both the Suir and Nore there is clear evidence of substantial accumulation of gravels and larger alluvial material in the downstream areas of weirs. These locations are frequently used by spawning adult sea lamprey in both rivers. Ducasse and Leprince (1980) have also reported use of such areas by spawning *Petromyzon* in the Gironde system. Such gravelled areas are not present to the same extent in the Barrow and this may reduce areas available for spawning.

Of the four channels in which sea lamprey were found, one discharged to the tidal waters while the Duiske discharged downstream of a major weir on the main channel. Kurz and Costello (1999) referred to anecdotal reports of sea lamprey spawning in the Duiske channel and the present study has shown the capacity of that channel to harbour large ammocoete populations. There is considerable habitat in tributary channels that are suitable for spawning by sea lamprey. However, the paucity of areas of fine sediment limits the potential development of sizeable populations of juveniles. Sea lamprey have access to tributaries but appear to avail but little of these. Similar findings were made in the Slaney catchment (King and Linnane 2004), where unimpeded access is available to sea lamprey into the Bann system. This system carried very high densities of juvenile river/brook lamprey but had a very low level of representation by sea lamprey.

The low level of occurrence, low density and fragmented population structure of juvenile sea lamprey mirrored the findings from the Slaney (King and Linnane 2004) and from other Irish systems (King and Lehane 2005). The findings point to an intermittent level of success in extent of penetration into upstream waters by adult migrants. This, in turn, affects the distribution of juveniles within the catchment as a whole. The higher up a system that adults can travel the greater amount of nursery and pre-metamorphosis waters available to juveniles. It is a common phenomenon in Europe that sea lamprey migration is impeded in the lower reaches of major catchments, limiting their opportunities to colonise widely (Assis 1990, Strevens 2003).

Given the highly fecund nature of adult sea lamprey females (Mannion 1968), such colonising would, potentially, have substantial benefit for the conservation status of the species. An exception to the common trend among sea lamprey data sets in Ireland is the Munster Blackwater (King and Linnane 2004). Here, sea lamprey juveniles were found to constitute a relatively high proportion of the total ammocoete population (in excess of 10% at some sites with n=30) and were found in headwaters, over 100 km from the upper tidal reaches. The population structure of sea lamprey juveniles in the Blackwater indicated that spawning occurred more frequently than in other Irish channels.

The poor findings in relation to sea lamprey in the Barrow identify, yet again, the seemingly tenuous status of this species in many Irish waters. It may be that the time has come to engage in clearly circumscribed intervention strategies designed to broaden the degree of upstream escapement and, hence, facilitate a greater dispersal of spawning effort. This in turn may impact positively on the distribution, population structure and density of juvenile populations into the future in catchments where such management is undertaken. Such intervention might include capture of adult migrants at known 'accumulation' points or upstream bottlenecks and their translocation to upstream locations within the same catchment where further migration can occur and where suitable spawning areas and juvenile settlement areas are available. Such movement would retain any genetic integrity, although it is considered that *Petromyzon* shows poor fidelity to natal waters (Bergstedt. and Seelye,1995).

## 5.3 Conservation Implications of catchment geomorphology and of management practises in the Barrow catchment

### *5.3.1 Availability of juvenile lamprey habitat*

For a channel to function successfully as lamprey habitat it must contain a balance of the niches required by the different life history stages (Maitland 2003). For the anadromous sea and river lamprey, a channel must provide unimpeded access from the sea to spawning areas, ideally as far up the catchment as possible. Spawning grounds must provide the appropriate type of bed material to permit redd excavation and egg deposition. However, it is imperative that a channel has extensive areas of deposition where fine sediments can accumulate. These deposits must be of a grain size that permits easy penetration and burrowing by ammocoetes or juvenile lamprey.

It is evident from the results in the present study that a substantial number of the channels within the SAC have a limited capacity to function as good habitat for all the life history stages of lamprey. The instream regime of several of the channels was very similar, with a flow pattern dominated by uniform glides, marginal growths of water celery vegetation and a bed of large gravel and cobble. These conditions were prominent in the Boherbaun, Stradbally, Lerr and Greese and were not conducive to instream physical diversity, in terms of flow or in terms of deposition of fines. The paucity of the latter at so many sites was considered to be a major factor impacting on distribution and status of juvenile lamprey. This was compounded by the particle size of the channel beds, which were, in general, too large or coarse for use as spawning habitat by brook lamprey.

In conservation management terms, the findings have considerable relevance for the SAC designation in regard to lamprey, with some channels clearly more important for lampreys than others. It is clear that the channels designated with SAC status have been so designated in respect of a number of qualifying elements, both Annex I habitats and Annex II species. A major element in the designation of the river channels selected was their role as spawning and nursery areas for Atlantic salmon. These habitat requirements are in direct contrast to those required by lamprey ammocoetes. In many cases, such as occurs on the Slaney SAC (see King and Linnane 2004), channels contain the suite of niches necessary to accommodate the habitat requirements of both salmon and lamprey. Such an accommodation does not occur as frequently in the Barrow tributaries, which tend to have a predominance of salmon habitat and limited areas of juvenile lamprey habitat. In contrast, the findings from the Black River, in the Mountain River catchment, identify this non-SAC channel as being very significant for juvenile lamprey and point to the appropriateness of consideration being given to the inclusion of this channel within the River Barrow – River Nore SAC.

### *5.3.2 Channel Management/Maintenance works:*

Dredging work, or channel maintenance, is undertaken by different agencies in different parts of the Barrow catchment. The area of catchment that was originally arterially drained in the 1930s is subject to maintenance by the Barrow Drainage Board. The area covered includes the R. Barrow main channel upstream of Carlow as well as a number of tributaries, some of which are designated within the SAC. Waterways Ireland also engages in channel maintenance, for navigation, along the navigable R. Barrow. In addition to these bodies, a number of channels are maintained by local District Drainage Boards.

Maintenance is undertaken to improve the hydraulic performance of a channel, in the context of engineering design criteria. The process removes features occurring in the cross-section that would tend to obstruct flow and/or that might create elevated stage or water height conditions. This would include debris, fallen timber or trees growing at a low level in the cross-section, areas of sediment accumulation – including lateral point bars, stands of emergent vegetation growing in the open water. The removal of areas of silt deposition has the potential to adversely impact ammocoete populations both directly, through loss of resident individuals, and indirectly, through loss of habitat. The removal of other features may impact indirectly as these features may have facilitated instream physical diversity, creating low velocity conditions locally where sediment accumulation could occur. Conversely, the installation of stone structures in arterially drained channels, designed to enhance the instream habitat for brown trout and salmon, can serve to focus flow and create backwater areas of sediment accumulation capable of accommodating ammocoete populations (M. O' Grady and F. Igoe pers. comm.).

A series of field-tested strategies (King *et al.* 2000), designed to render channel maintenance practises more environmentally-sensitive, has recently been adopted by the OPW and is being implemented as that body's national policy in this area. It is planned that further scientific studies will be undertaken to identify impacts and appropriate mitigations in respect of maintenance impacts on a range of Annex II species, including lamprey. In relation to the Moy catchment, O'Connor (2004) alluded to the possible adverse effects of the arterial drainage programme in that catchment on lamprey ammocoete populations and habitat. It is certainly the case that drainage work and, commonly, maintenance serve to create a strong degree of uniformity within a channel in regard to hydraulic regime, gradient and instream appearance. Such developments tend to reduce diversity. Channels commonly are over-wide, ecologically, and sediment deposition is widely dispersed. This prevents accumulation in a manner that would accommodate substantial ammocoete populations. To date, no cause-and-effect links have been scientifically made between channel work and ammocoete populations. However, it is clear that potential for severe adverse impact does exist and it will be important to quantify this, to assess recovery patterns and rates and to identify practical mitigation strategies.

### 5.4 Status of Barrow SAC for lampreys relative to other SACs surveyed

In catchment terms, the Barrow system must be seen as impoverished in terms of ammocoete populations when compared to other Irish catchments recently studied. These catchments include the Slaney and Munster Blackwater (King and Linnane 2004) and the Moy (O'Connor 2004). The Barrow had a higher percentage of negative sites than the other systems. However, the range of density values found on the Barrow was comparable to those found in these other systems. The density distribution pattern found in the Barrow, with a predominance of negative sites and a trend towards decreasing numbers of sites with increase in density value, was also found in a larger national study carried out across a range of channels in various Irish catchments during 2004 (King and Lehane 2005).

A particular feature of the Barrow catchment was the recurrence of persistent negative results throughout individual channels. It has not been unusual to find negative sites on a discrete basis but the recurrence of negative sites along individual channels and the absence of patches of suitable sediment was unique to the Barrow, among the Irish catchments studied to date. The paucity of sea lamprey, both in terms of density and extent of distribution, was mirrored in findings from the Slaney system (King and Linnane 2004). Both of these catchments contrasted with the Munster Blackwater catchment, where juvenile sea lamprey were recorded up to the headwaters and were commonly recorded in many tributaries (King and Linnane 2004). O'Connor (2004) also recorded a greater prominence of sea lamprey in the Moy system, compared to the present findings from the Barrow.

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