National Programme: Habitats Directive and Red Data Book Fish Species

Summary Report

2018

IFI/2020/1-4493

Iascach Intíre Éireann
Inland Fisheries Ireland

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Habitats Directive Report 2018

1. Introduction

Inland Fisheries Ireland (IFI), on behalf of the Department of Communications, Climate Action and the Environment (DCCAE), is responsible for reporting on the fish species (Table 1.1) listed in Annex II/V of the EU Habitats Directive (Council Directive 92/43/EEC). Data collected from the monitoring programme in 2018 represented the final instalment in the current 6-year reporting cycle under Article 17 of the Directive and will be used to assess the conservation status of each of the fish species. The Habitats Directive (HD) team within IFI's Research and Development Division, in addition to fulfilling the reporting requirements, also monitors 2 fish species of conservation interest listed in the Red Data Book (King *et al*., 2011), namely, Arctic char (*Salvelinus alpinus*) and smelt (*Osmerus eperlanus*).

Table 1.1. Status of the lamprey, shad and pollan species.

	Habitats Directive	**Red Data Book**
Sea lamprey *(Petromyzon marinus)*	Annex II	Near threatened
River lamprey *(Lampetra fluviatilis)*	Annex II, V	Least concern
Brook lamprey *(Lampetra planeri)*	Annex II	Least concern
Twaite shad *(Alosa fallax fallax)*	Annex II, V	Vulnerable
Killarney shad *(Alosa fallax killarnensis)*	Annex II, V	Vulnerable
Pollan *(Coregonus autumnalis)*	Annex V	Vulnerable

Two important elements of the monitoring programme for lampreys involved surveys for sea lamprey spawning activity in late spring/early summer, followed by catchment-wide surveys for larval lampreys in late summer/early autumn. A period of exceptionally warm and dry weather during the summer of 2018 led to low water levels in rivers and water temperatures that exceeded 20°C at times. This created stressful conditions for fish populations, precluded electrofishing operations on occasion and resulted in a prolonged sampling period due to repeat site visits. Walk-over surveys on the main stems of the Rivers Feale and Deel (Moy catchment) were carried out to assess the extent of sea lamprey spawning. A suite of known spawning hotspots in SAC rivers were also visited on a number of occasions as part of an on-going monitoring programme to assess annual variations in breeding effort. Catchment-wide larval lamprey surveys, involving a total of 147 sites, were conducted on the Nore and Moy SAC rivers.

Annual twaite shad (*Alosa fallax*) investigations are focused on egg kick-sampling surveys, to determine spawning extent, and sampling for juvenile young-of-year shads as part of IFI's

suite of estuarine sampling programmes. Spawning grounds for twaite shad on the Rivers Nore and Barrow were confirmed in 2017 and, pending genetic analysis of eggs, potential spawning sites have been identified on the Rivers Suir and Munster Blackwater in 2018. Seine netting surveys at a number of sites on the Barrow, Slaney and Munster Blackwater estuaries were targeted in 2018 for juvenile shads and trawling surveys were carried out on the Munster Blackwater and Barrow-Suir estuaries. These netting and trawling surveys also provided data on the distribution and abundance of juvenile smelt.

Seasonal pelagic netting surveys for pollan were carried out on the 3 pollan lakes within the Republic of Ireland (Lochs Allen, Ree and Derg) during 2015 - 2017. In 2017 and 2018 the focus shifted to identifying potential spawning grounds for this Annex V species in Lough Allen. Very little is known about the spawning habitat preferences in Irish lakes but potential sites, characterised by smaller cobble/pebble/gravel substrates, were identified and mapped.

The relatively new technique of collecting environmental DNA (eDNA) has been used previously to investigate sea lamprey presence in the Mulkear and Munster Blackwater catchments (Bracken *et al*., 2019). This technique has great potential for Habitats Directive monitoring as sampling for Annex II fish species can pose challenges using more traditional sampling techniques. The timing of upstream migration/spawning of twaite shad and sea lamprey roughly coincides and the eDNA sampling technique was employed in the current reporting period to investigate the presence of both species in 4 estuaries. The estuaries, namely the Boyne, Liffey, Lee and Ilen, have historical records for Annex II fish and/or are deemed to provide potential spawning opportunities for these species.

An additional task in 2018 involved the HD project team assisting colleagues from Portugal on the EVOLAMP (Genomic footprints of the evolution of alternative life histories in lampreys) project. This project, with a lifespan from 2018 – 2021, is coordinated by the University of Évora, with the technical-scientific support of MARE (Marine and Environmental Sciences Centre). It is funded by the Portuguese Foundation for Science and Technology and participating institutions include IFI, University of Basel and University of Durham. The objective of the project is to investigate the molecular basis of alternative life histories in lampreys, through analysis of different life stages of two closely related species with distinct life cycles, the non-parasitic and freshwater resident European brook lamprey (*Lampetra planeri*) and the parasitic and migratory European river lamprey (*Lampetra fluviatilis*). The Habitats team facilitated the collection of a number of life-history stages of these 2 species and the processing of samples for further analysis.

Barriers to fish passage, in the form of weirs, bridge aprons and other built structures within rivers, constitute a significant pressure to Annex II fish species, given their migratory

behaviour. A programme of surveying all major barriers in the main stem SAC channels is nearing completion, with the focus on the Nore, Suir and Munster Blackwater in 2018. Identifying real and potential barriers to migration in SAC channels will feed into the conservation measures element of Habitats Directive reporting with a view to mitigating access issues to freshwater spawning grounds for these Annex II fish species.

2. Lamprey Programme

2.1 Larval Lamprey Investigations

2.1.1 Nore Catchment Wide Survey

The Nore catchment in the midlands-southeast drains an area of 2600km^2, principally across Co. Kilkenny but also including small portions of Cos. Laois, Carlow and Tipperary. The Nore comprises several significant tributaries, principally the Erkina, Dinin and Kings rivers as well as a significant main channel section. The river rises in upland area to the east of Moneygall from where it is joined by smaller tributaries such as the Delour, Tonet and Mountrath rivers flowing from the southern slopes of the Slieve Bloom Mountains (Figure 2.1). Large sections of the main channel and some of the tributaries possess SAC designation (River Barrow and River Nore - 002162). Relevant features of interest in this SAC include freshwater pearl mussel (*Margaritifera margaritifera*), white-clawed crayfish (*Austropotamobius pallipes*), sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*), river lamprey (*L. fluviatilis*), twaite shad (*Alosa fallax*) and Atlantic salmon (*Salmo salar*). Notably, there is also the extremely rare Nore freshwater pearl mussel (*M. durrovensis*) with a limited geographic distribution within the catchment.

Plate 2.1. A section of the upper Nore near Borris-in-Ossory, Co. Laois.

The Nore catchment contains several urban centres, namely Kilkenny City, Mountrath, Abbeyleix, Urlingford, Castlecomer, Bennettsbridge, Callan and Thomastown. Discharges from these various population centres, in conjunction with agricultural, forestry and peat extraction activities in rural environs, constitute significant sources of pressure upon the catchment through pollution, eutrophication and siltation. Historical arterial drainage has affected the form and function of many sections of both main river and tributary

watercourses. Numerous low-head barriers to fish migration are present throughout the catchment (Sullivan, 2007; Gargan *et al*., 2011). The impact of two of these on the main river channel have been ameliorated, by remedial works at Lacken weir in Kilkenny City and at Thomastown by breaching in flood flows. Significant structures remain in Bennettsbridge and Kilkenny City.

Data regarding the ecological status of rivers in the Nore catchment is most recently available for the period 2010-2015 (EPA, 2018). Of 123 sections or 'waterbodies' identified, 5 had 'High' status, 46 had 'Good', 21 were deemed 'Moderate', 17 were 'Poor', none were 'Bad' and 34 were 'Unassigned'. No overall improvement was in evidence from the previous reporting cycle, if anything there was a slight deterioration. The 5 sections considered 'High' were clustered in the upper catchment, belonging to the Delour-Tonet system flowing from the Slieve Bloom Mountains. At subcatchment level, the Erkina, Dinin and Kings rivers possessed channels varying from 'Good' through 'Moderate' to 'Poor'. The main stem Nore was largely 'Good'. Almost 50% of the waterbodies assessed were deemed 'at risk' from anthropogenic pressures such as agriculture, urban and domestic wastewater and diffuse inputs, industry, forestry, mining and quarrying. Excess phosphates and elevated levels of nitrates and ammonia were considered the largest threats to aquatic ecosystem health, and significant work would be required to protect and restore water quality across the Nore catchment.

Plate 2.2. The Delour River in the Slieve Bloom Mountains, Co. Laois.

A variety of lamprey monitoring studies have been conducted on the Nore to date. Commissioned surveys by OPW were undertaken by IFI during the Kilkenny city flood relief

scheme (2002 – 2006), allowing data collection on impact of the scheme locally (King et al 2015) as well as permitting comparative data collection in the Nore main stem and tributaries adjacent to Kilkenny. Connor (2006) undertook larval surveying in 2004 at selected sites along the main channel as well as on the Erkina and Dinin tributaries. Float-over surveying along the lower stretches of the main channel downstream of Kilkenny City on six occasions since 2000 has demonstrated successful sea lamprey migration and spawning. Annual sea lamprey hot-spot surveys in Thomastown have confirmed consistent spawning on the main channel Nore at this location. The Dinin was chosen in 2013 as a larval reference channel for the Habitats Directive Monitoring Programme, with sites (n=5) repeat-surveyed on a yearly basis. A larval survey in 2008 complemented the earlier work of Conor (2006) and sampled subcatchments not previously examined. A full catchment wide larvae survey across the entire Nore system was not undertaken until 2018.

Plate 2.3. The Dinin River near Old Leighlin on the Carlow-Kilkenny border.

A total of 104 sites throughout the Nore catchment were preselected for survey, however 27 of these locations could not be electrofished when visited due to exceptional drought and/or elevated water temperatures. Semi-quantitative electrofishing was undertaken at all sites where conditions were suitable. Surveying was not possible at one additional site due to a lack of suitable larval habitat. *Lampetra spp*. larvae (total n=974) were encountered at 71 (93%) of the 76 sites surveyed with suitable habitat (Table 2.1). A broad range of age classes (17-165mm) were represented (Figure 2.2). Densities of river/brook larvae at positive sites ranged from 1-54 individuals per m^2, with an overall mean of 12 larvae per m^2 (Figure 2.3). A single *Lampetra spp* transformer (147mm) was captured at a site on the Erkina. No sea lamprey larvae were encountered. All the targets outlined in the Common Standards Monitoring for these species (JNCC, 2015) were met across the Nore catchment, thus inferring that favourable conditions currently prevail.

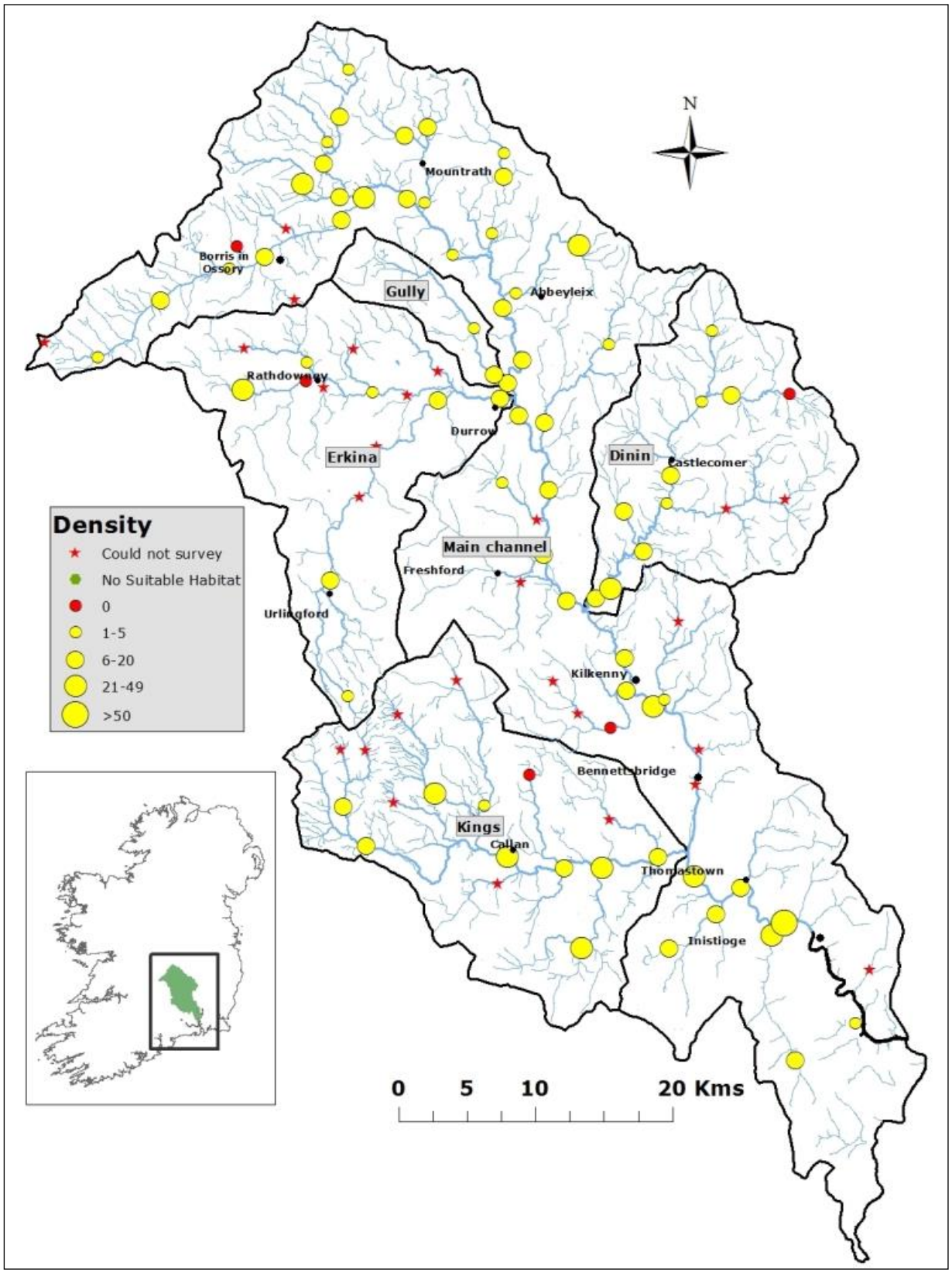


Figure 2.1. Map outlining sampling locations (n=104) across the Nore catchment for lamprey larvae, July-August 2018.

Table 2.1. Distribution, density and population structure of larval populations across the Nore catchment, July to August 2018.

Channel Name & Size (km^2)	No. Sites	No Suitable Habitat	No Survey	No. Positive Sites	Max. Density ($Fish/m^2$)	Min. Density ($Fish/m^2$)	Mean Density ($Fish/m^2$)	Max. Length (mm)	Min. Length (mm)
Dinin (304)	12	0	2	9	21	2	7	150	17
Erkina (386)	15	0	7	7	35	1	9	152	41
Gully (57)	2	0	0	2	13	2	8	122	39
Kings (440)	18	0	8	9	44	2	18	137	20
Main Channel (1687)	57	1	10	44	54	1	12	165	17
Total	104	1	27	71					

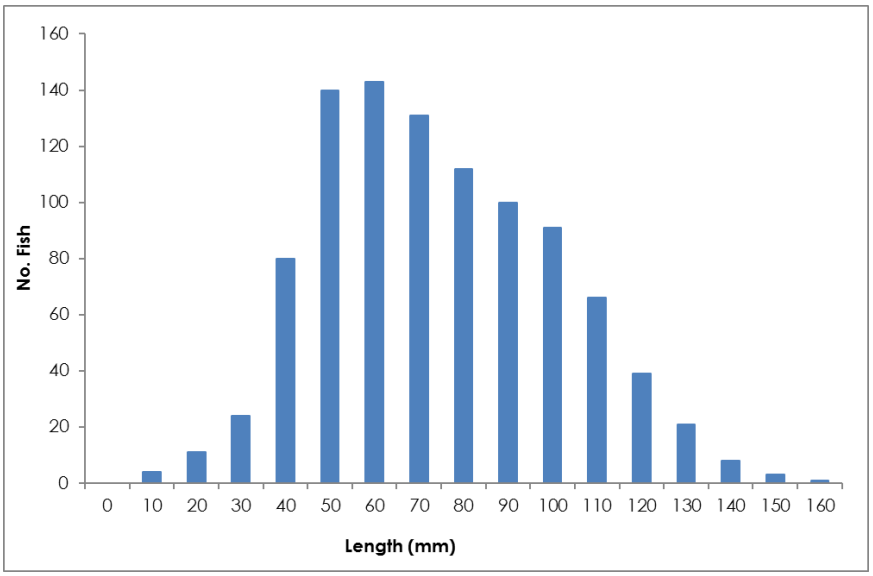


Figure 2.2 Length frequency distribution of *Lampetra* spp. larvae captured at locations across the Nore catchment in 2018 (n=974).

Results for individual sub catchments, including survey locations, length frequency distributions and density estimates, are contained in Figures 2.4 to 2.8. Presence was recorded throughout the catchment, with larvae frequently located in the upper sections and head waters of tributary streams. It can be concluded that populations of *Lampetra* spp. exist at a favourable status in the Nore catchment. The status of *P. marinus* populations, however, remain unfavourable.

Plate 2.4. A weir on the River Nore at Castletown, Co. Laois, modified by installation of a rock-ramp fish pass.

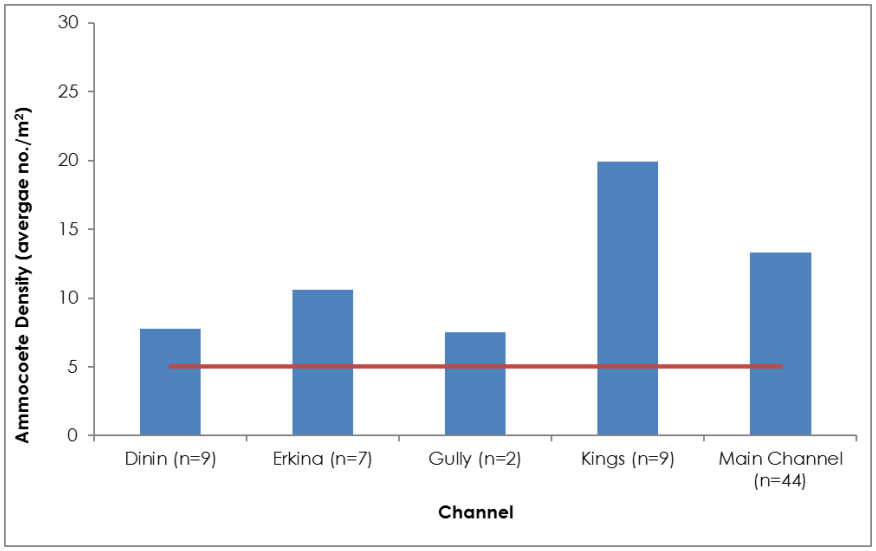


Figure 2.3. Comparative densities of *Lampetra* spp. larvae recorded on tributary and main stem channels of the Nore catchment during 2018. The red horizontal line indicates minimum density (5 larvae/m^2) required to signify favourable condition (Common Standards Monitoring Guidelines, JNCC, 2015).

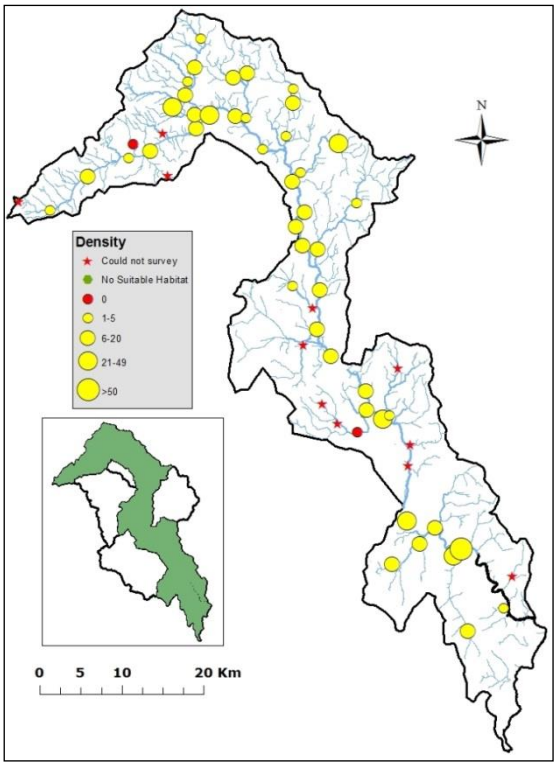


Figure 2.4a. Sampling locations (n-=57) along the main channel Nore.

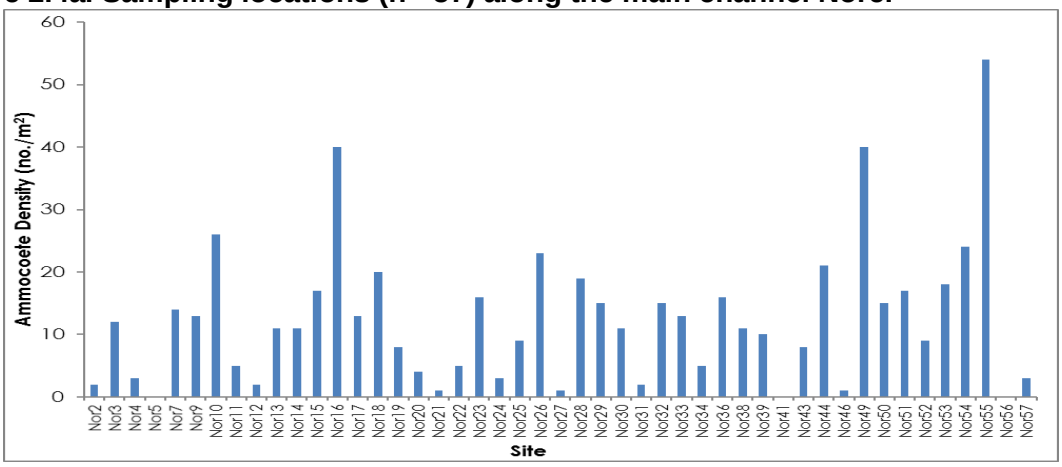


Figure 2.4b. Population densities of larvae at individual survey sites (n=47) along the main channel Nore.

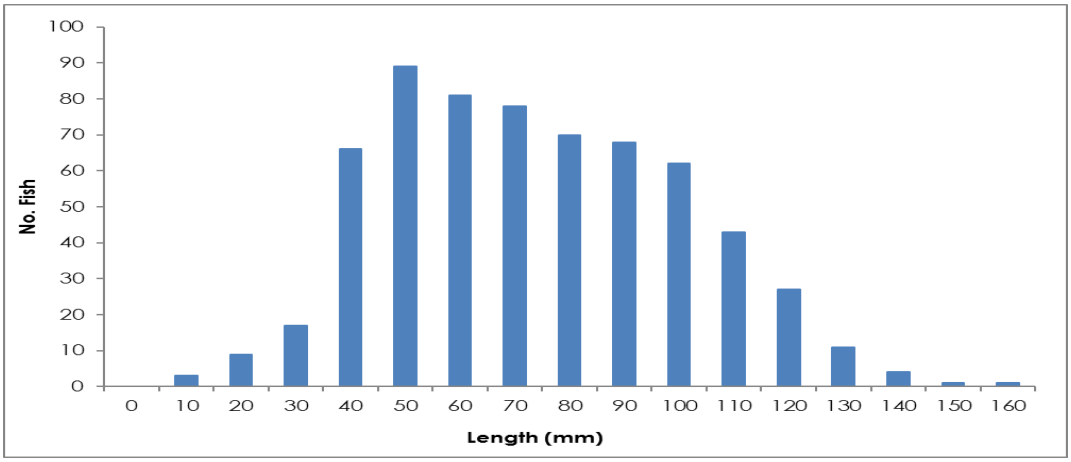


Figure 2.4c. Pooled length frequency distribution for larvae (n=630) captured on the main channel Nore.

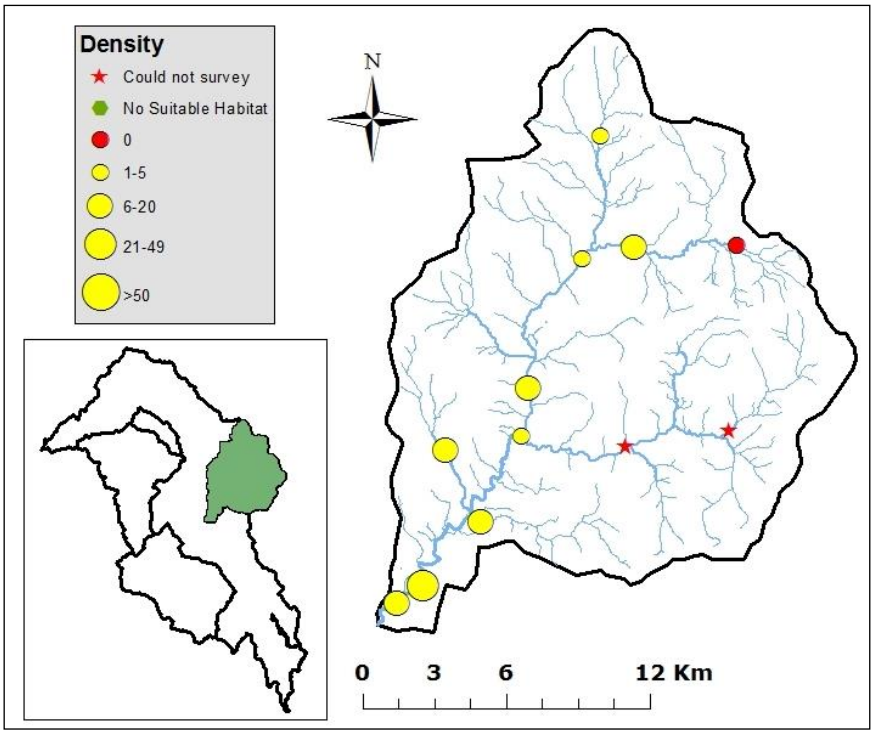


Figure 2.5a. Sampling locations (n=12) within the Dinin sub-catchment.

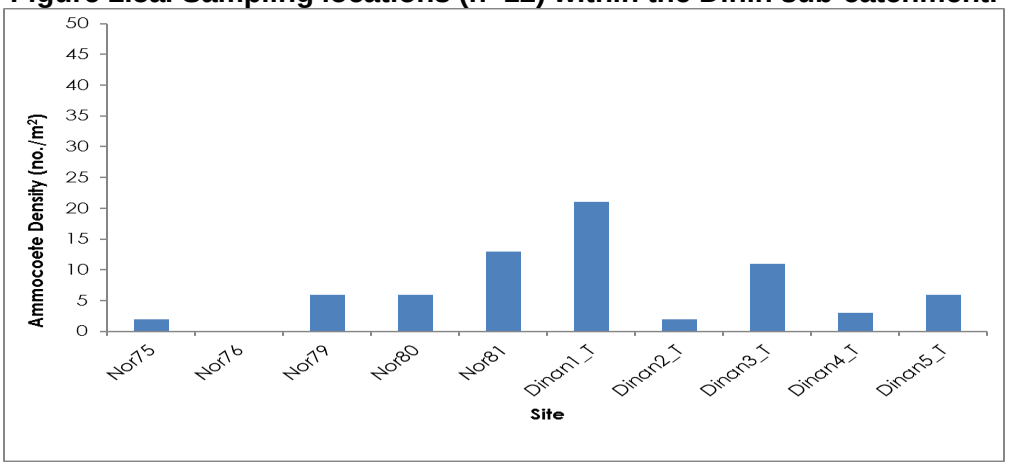


Figure 2.5b. Population densities for larvae captured at individual survey sites (n=10) within the Dinin sub-catchment.

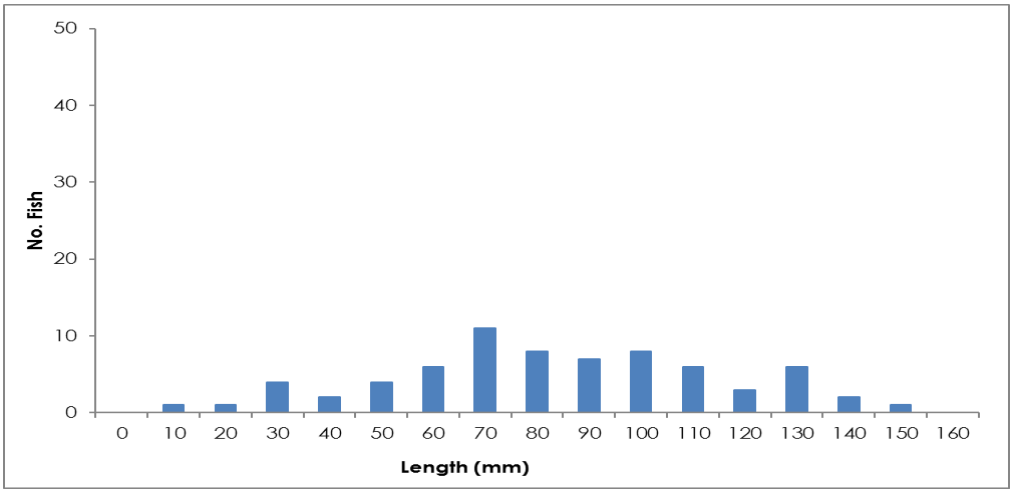


Figure 2.5c. Pooled length frequency distribution for larvae (n=70) captured across the Dinin sub-catchment.

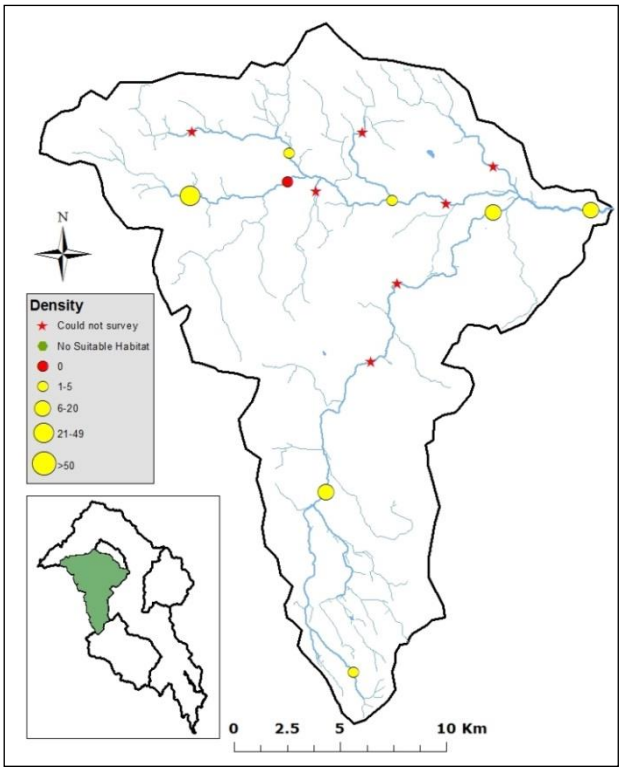


Figure 2.6a Sampling locations (n=15) within the Erkina sub-catchment.

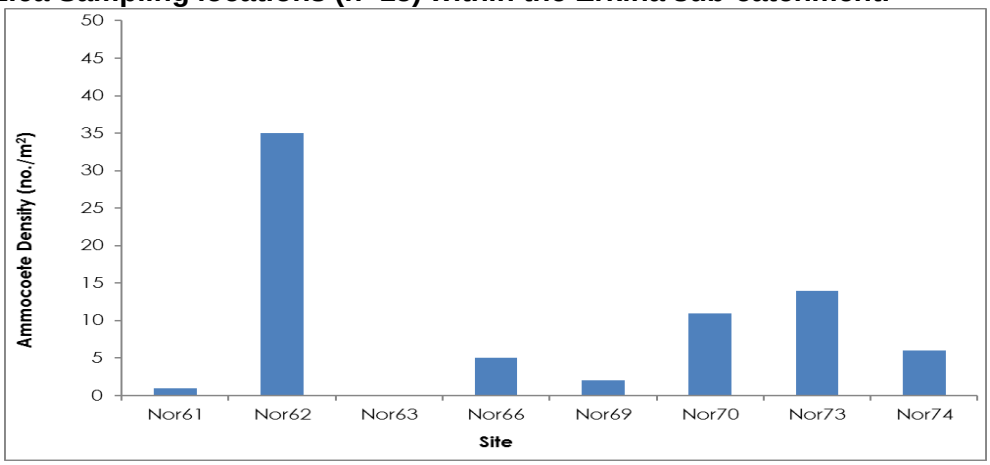


Figure 2.6b. Population densities for larvae captured at individual survey sites (n=8) within the Erkina sub-catchment.

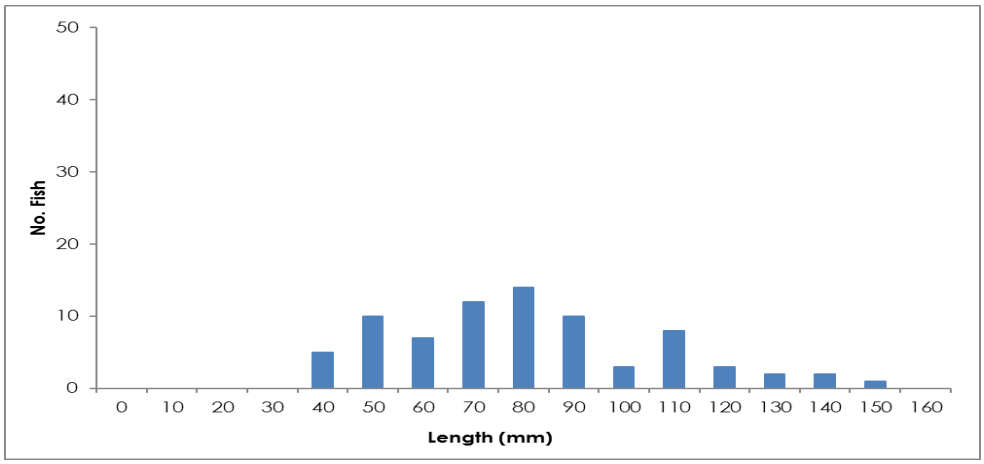


Figure 2.6c. Pooled length frequency distribution for larvae (n=77) captured across the Erkina sub-catchment.

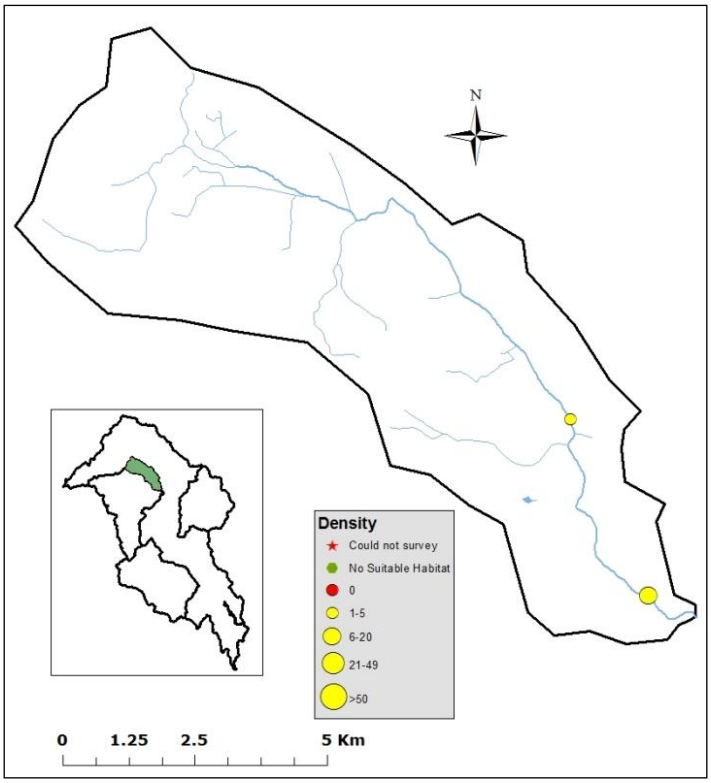


Figure 2.7a Sampling locations (n=2) in the Gully sub-catchment.

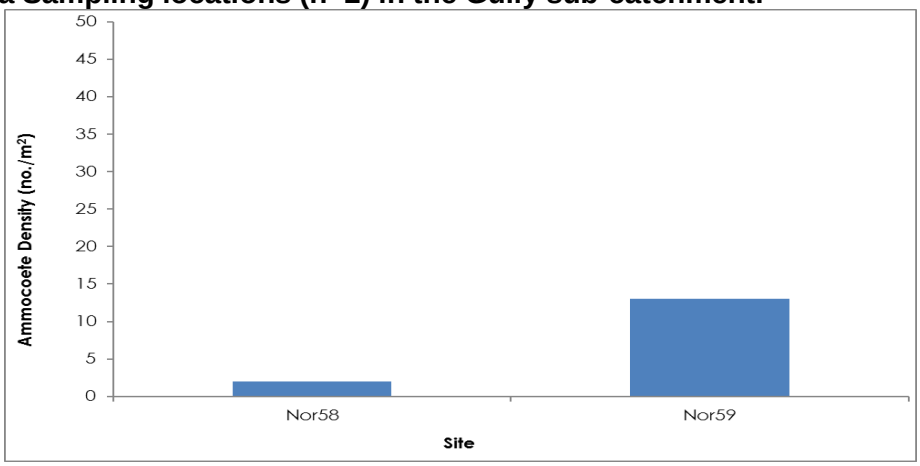


Figure 2.7b. Population densities for larvae captured at individual survey sites (n=2) in the Gully sub-catchment.

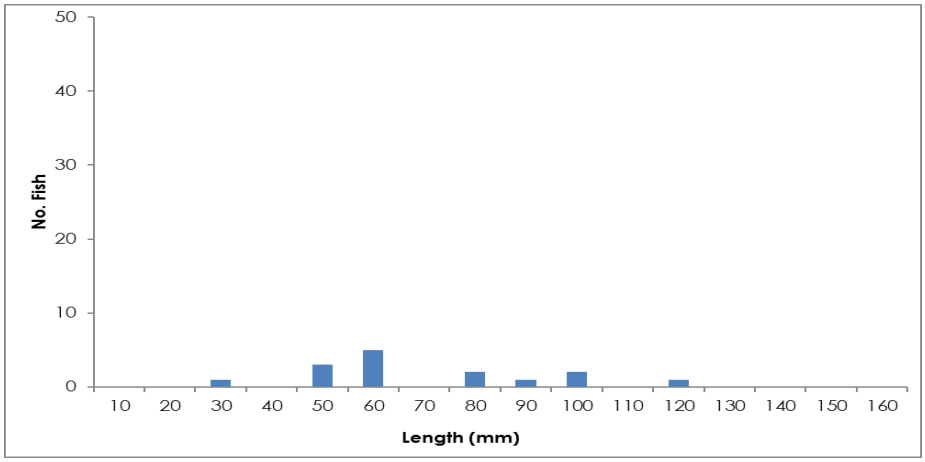


Figure 2.7c. Pooled length frequency distribution for larvae (n=15) captured across the Gully sub-catchment.

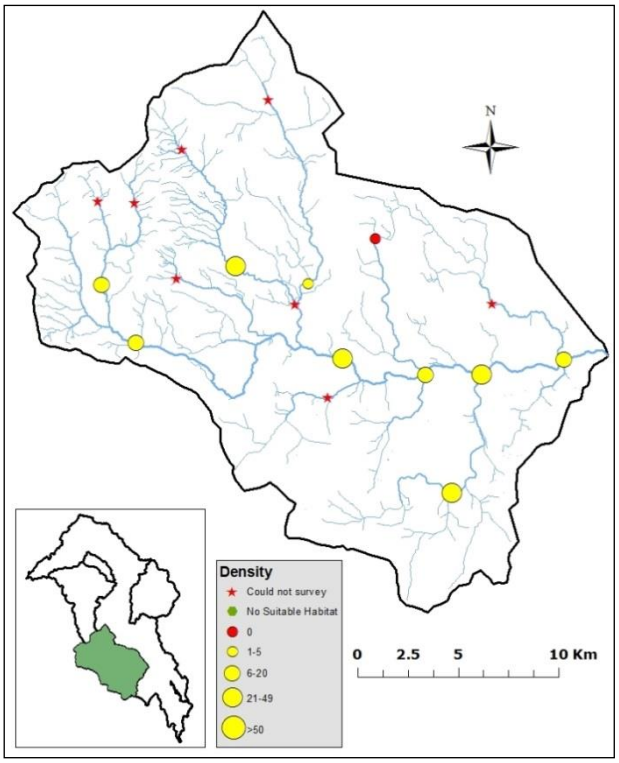


Figure 2.8a. Sampling locations (n=18) across the Kings River sub-catchment.

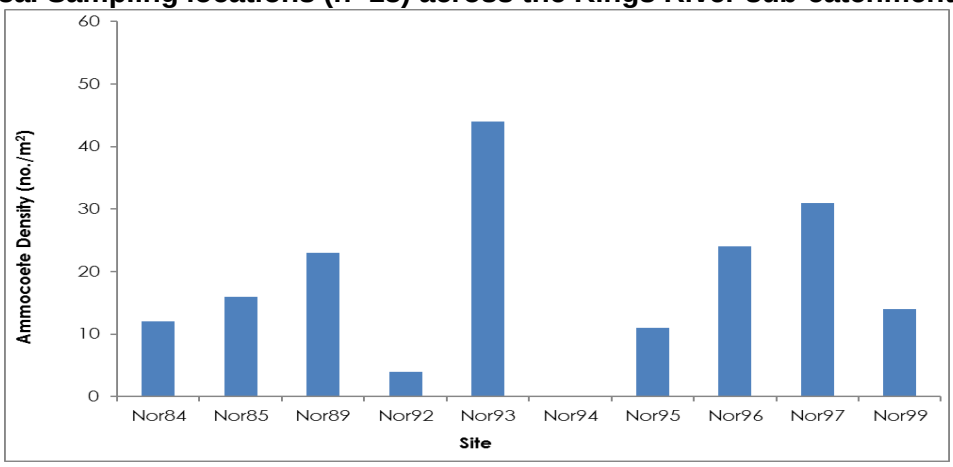


Figure 2.8b. Population densities for larvae captured at individual survey sites (n=10) across the Kings River sub-catchment.

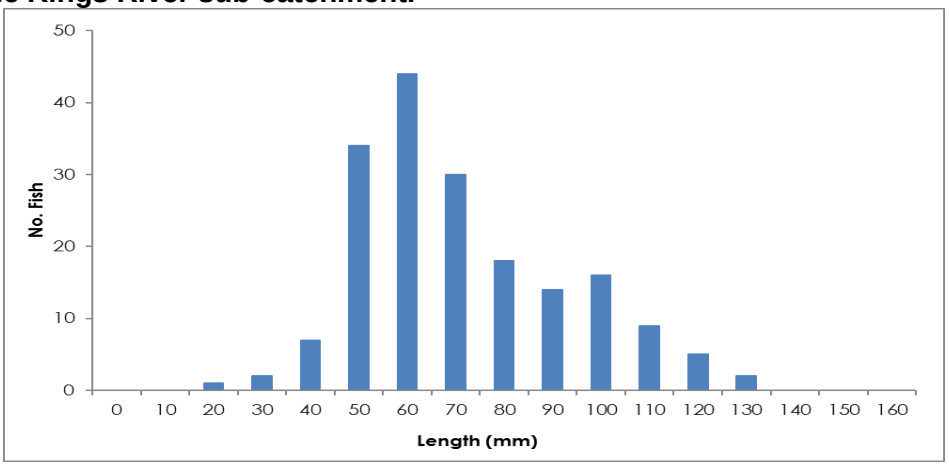


Figure 2.8c. Pooled length frequency distribution for larvae (n=182) captured across the Kings River sub-catchment.

Plate 2.5. Citizen Science – helping IFI staff measuring larvae on the River Dinin, Castlecomer, Co. Kilkenny.

2.1.2 Moy Catchment Wide Survey

The Moy catchment, located in the west of Ireland, drains an area of 2,100 km^2. The River Moy rises in the Ox Mountains in the north-eastern section of the catchment, from where it flows south-west for approximately 65 km before turning north and flowing for a further 25 km towards the sea at Killala Bay. Major tributaries include the Deel, Clydagh, Castlebar, Manulla, Gwestion, Trimoge and Owengarve, while the western part of the catchment is dominated by Loughs Conn and Cullin and their tributaries (Figure 2.9). The Moy catchment lies primarily on carboniferous limestone bedrock but there is a strip of harder sedimentary and metamorphic rocks with a small amount of granite running from the south-west to the north-east along the line of the Ox Mountains (McGarrigle *et al.,* 1998). The two largest urban centres within the catchment are Ballina and Castlebar, with smaller populations occurring in the towns of Foxford, Swinford, Kiltimagh and Charlestown.

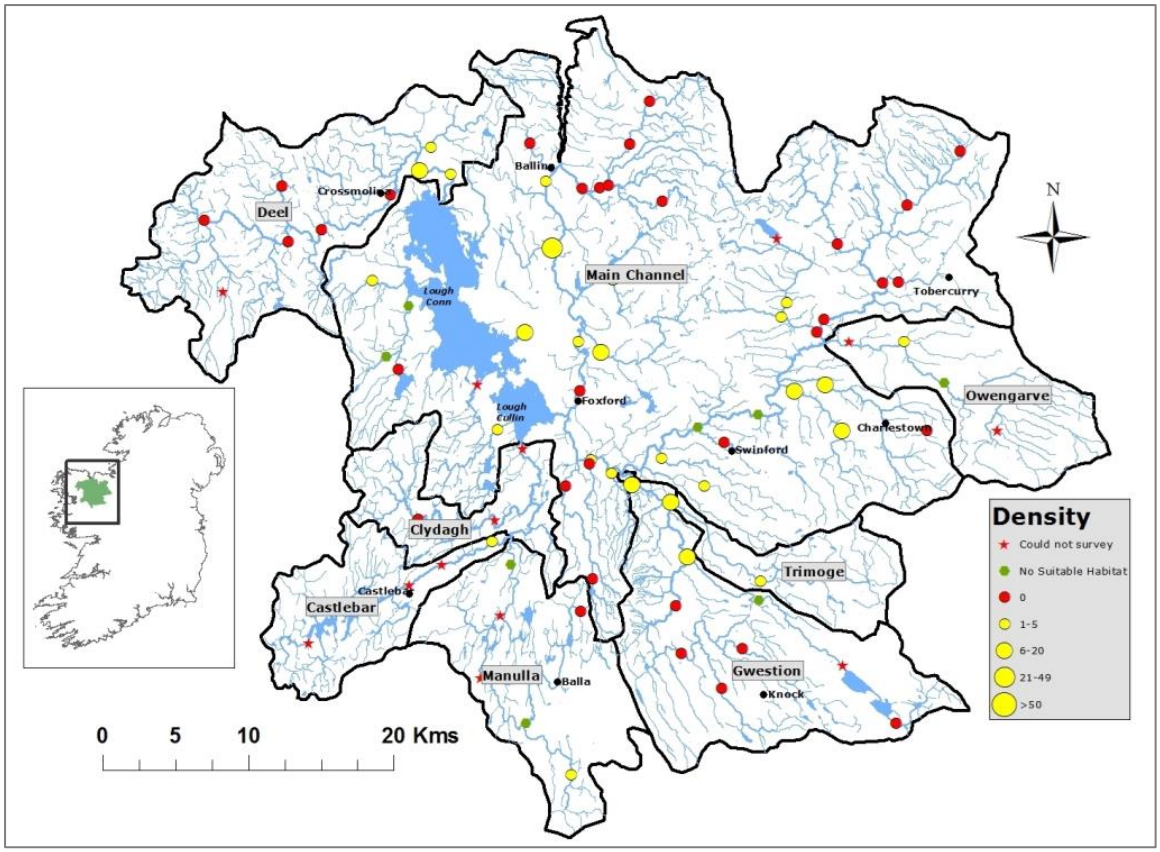


Figure 2.9. Map of the Moy catchment showing larval lamprey densities for August/September 2018.

As well as being one of Ireland's premier salmon rivers, almost the entire freshwater element of the River Moy with its tributaries and lakes (including Loughs Conn and Cullin), make up the River Moy SAC (Site code: 002298). This Special Area of Conservation is important for a number of species listed in Annex II of the E.U. Habitats Directive, namely sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*), Atlantic salmon (*Salmo salar*), white-clawed crayfish (*Austropotamobius pallipes*) and otter (*Lutra lutra*).

Plate 2.6. Site on the River Deel with no suitable spawning habitat for larval *Lampetra* spp.

In the 2010 – 2015 classification of ecological status (EPA, 2018), 57% of assessed river and lake water bodies in the Moy and Killala Bay catchment had good or high status and 19% were less than good. Tributaries of the Moy main channel (Addergoole, Sonnagh, Charlestown Stream, Black), Deel (Shanvolahan), Gwestion (Yellow, Cloonlavis, Glore) and water bodies within the Manulla and Trimoge sub-catchments were included in the 19% assigned at less than good status. The Castlebar River, in particular, was notable for having a high proportion of channel with a moderate or poor ecological status. Of the 6 transitional and coastal water bodies, only 2 were assessed: Killala Bay had a good status while the Moy estuary was moderate. The 2010 - 2015 assessment identified 16% of river and lake water bodies as being *at risk* of not meeting their WFD objectives, while the Moy estuary is also at risk and is impacted by eutrophication. Hydromorphological conditions and poor habitat quality, along with excessive nutrient loss from agricultural practices (diffuse and point) and waste water (urban and domestic) are identified as significant pressures on these at risk water bodies.

Plate 2.7. Lough Conn on the Moy Catchment.

The Moy catchment was subjected to a major arterial drainage scheme during the 1960s with the objective of increasing agricultural productivity in the area. This scheme had a major impact on the hydrology, ecology and fisheries of the catchment and resulted in the loss of a number of lakes in the southern part of the catchment and the reduction in size of others, such as Lough Conn (McGarrigle *et al*., 1998). The impact of these drainage works on lamprey populations is likely to have been severe at the time, with the widespread loss of larval lamprey and the removal of associated spawning and nursery habitat. Uniform, high-banked channels with a poor diversity of instream habitat are characteristic of the Moy catchment today and the current survey identified a general paucity of suitable nursery habitat for lampreys.

Plate 2.8. Site on the Crumlin River west of Lough Cullin.

Results

A total of 84 sites were pre-selected as part of a catchment-wide survey for larval lampreys on the Moy main channel and its tributary rivers. Sampling was carried out over a two-week period between 27th of August to 6th of September, 2018. As discussed, the Moy catchment has a high proportion of modified channel and 14 sites could not be sampled due to inaccessibility (high banks) or because they were too deep or had no suitable nursery habitat. Sub-catchments where this was particularly relevant include the Castlebar, Manulla and Owengarve rivers (Figure 2.9). A semi-quantitative sample was taken at each site by electrofishing for 2 minutes in a defined area ($1m^2$) of suitable nursery habitat, generally comprising fine sediments. As young-of-year larvae can be difficult to capture using this method, a quantitative pushnet sample was also taken from adjacent suitable areas of deposition if available. Water temperature and conductivity were measured at each site and habitat characteristics were noted, including sediment type, water depth, flow type, tree cover and extent of instream vegetation.

Of the 70 sites that were sampled, 62 (88%) had suitable nursery habitat. A total of 185 river/brook larval lampreys (*Lampetra* spp.) were recorded across the catchment (Figure 2.10), with the highest density (36 fish/m^2) occurring at a site on the main channel located approximately 5km upstream of Ballina town. Although it is not possible to distinguish between the larval stages of river (*Lampetra fluviatilis*) and brook lamprey (*Lampetra planeri)*, these are likely to be brook lamprey as there are no records for river lamprey on the Moy catchment. Sea lamprey larvae were not recorded in the current survey. The reason for this is uncertain and may be an indication of low numbers of adult spawning fish or of habitat use of deeper water by the larvae of this species. Adult sea lampreys are occasionally observed on the main channel of the Moy and there are a number of records for feeding juvenile sea lampreys from Lough Conn in the late 1950s (Inland Fisheries Trust, 1962) and more recently (King & O'Gorman, 2018). *P. marinus* larvae have been recorded in a previous catchment-wide study of larval lampreys (O'Connor, 2004).

One of the targets in the Common Standards protocol for monitoring populations of brook and river lampreys (JNCC, 2015) is that, in order to achieve favourable condition, larval *Lampetra* spp. should have a mean density >5/m^2 in sites with suitable habitat within a catchment. They should also be present in not less than 50% of these sites and the full range of size classes, from 0+ to metamorphosis, should be present. Results from the current survey reveal that the Moy catchment had a mean larval density of 3/m^2 and that *Lampetra* spp. occurred in 47% (n=29) of sites with suitable habitat. The full range of age classes was encountered with lampreys measuring 20mm – 132mm and with a mean length

of 66mm (Figure 2.11). Three transformers were recorded and these measured 97mm, 103mm and 108mm. Based on these criteria for larval lamprey, populations of *Lampetra* spp. do not achieve favourable condition in the Moy catchment. Similarly, at a sub-catchment scale, mean densities of ≤5/m^2 were recorded for all of the sub-catchments, with the highest mean density (5/m^2) recorded in the Trimoge (Table 2.2).

Table 2.2. Summary information on distribution, density, population structure of lamprey larvae across the Moy catchment, between August and September 2018.

	No. Sites	No Suitable Habitat	No Survey	No. positive Sites	Max. Density (Fish/m^2)	Min. Density (Fish/m^2)	Mean Density (Fish/m^2)	Max. Length (mm)	Min. Length (mm)
Castlebar (96 km^2)	4	0	3	1	1	1	1	98	98
Clydagh (83 km^2)	3	1	2	0	-	-	-	-	-
Deel (234 km^2)	9	1	1	3	9	1	1	116	62
Gwestion (228 km^2)	9	2	1	2	9	8	1	103	43
Main Channel (1109 km^2)	44	8	2	17	26	1	2	127	20
Manulla (164 km^2)	7	5	2	2	1	2	1	132	89
Owengarve (124 km^2)	5	4	3	1	1	1	1	86	86
Trimoge (69 km^2)	3	3	0	3	11	2	5	50	112

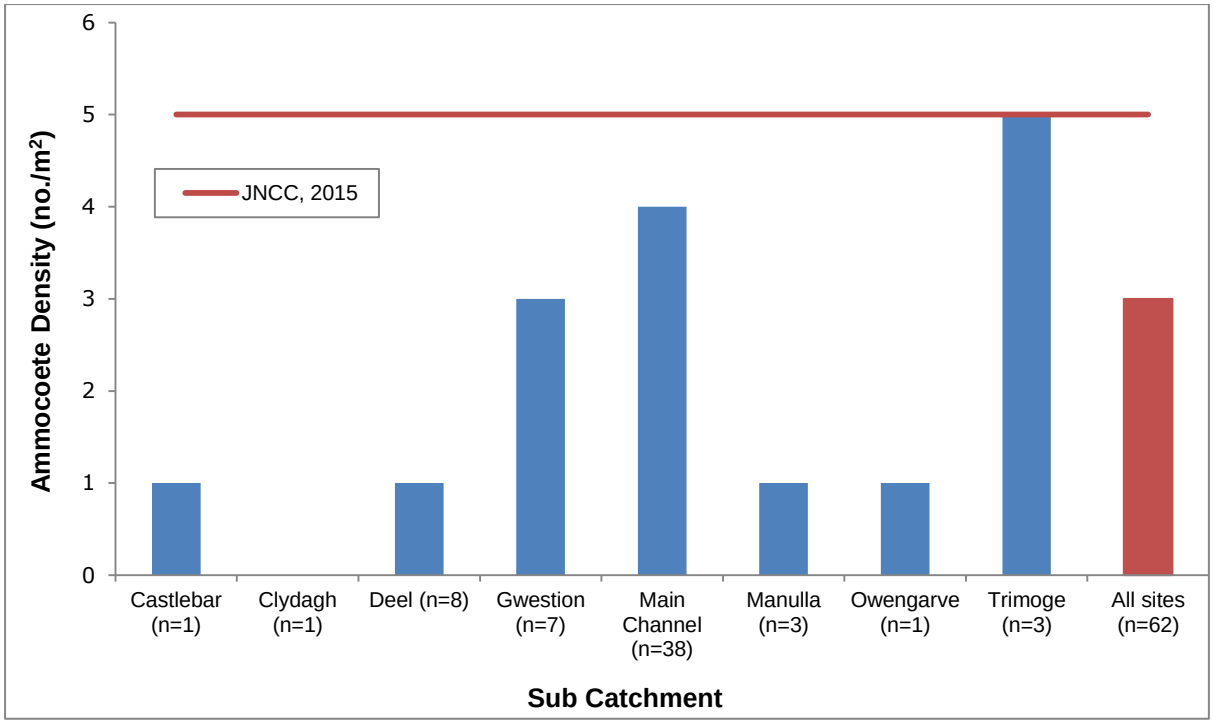


Figure 2.10. Mean densities of *Lampetra* spp. larvae recorded from tributary and main stem channels of the Moy catchment in 2018 (sites which could not be surveyed or had No Suitable Habitat, were removed from mean density calculations).

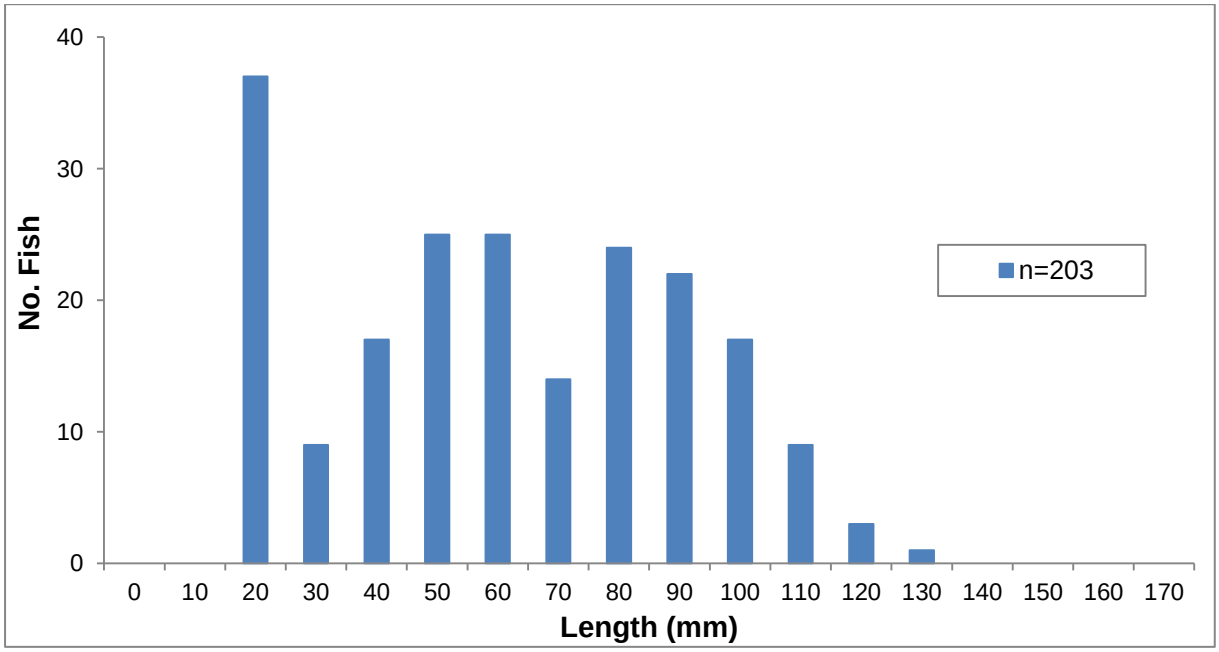


Figure 2.11. Length frequency distribution of *Lampetra* spp. larvae from all sites in the Moy catchment in 2018.

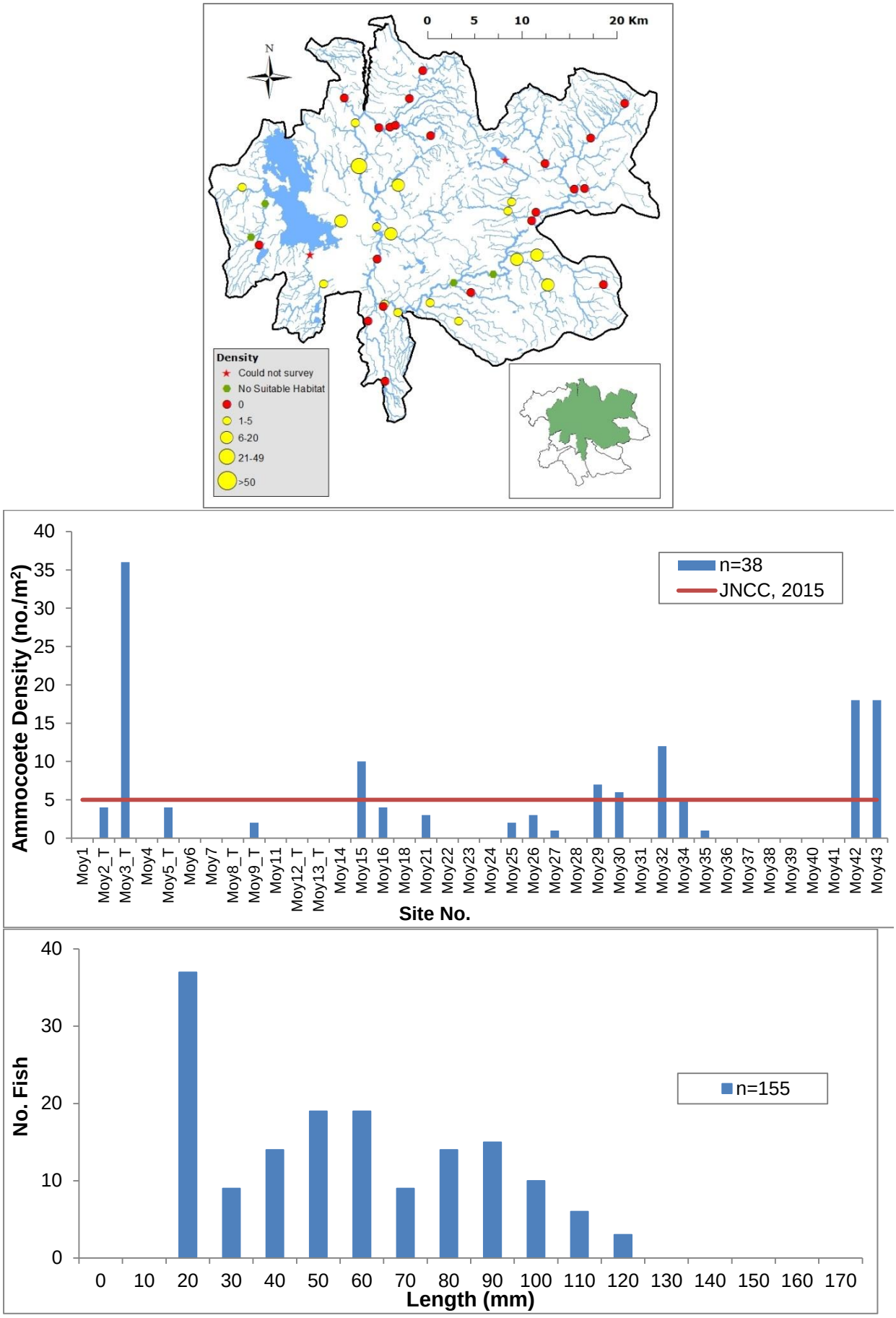


Figure 2.12. *Lampetra* spp. larvae results for the main channel of the Moy in 2018.

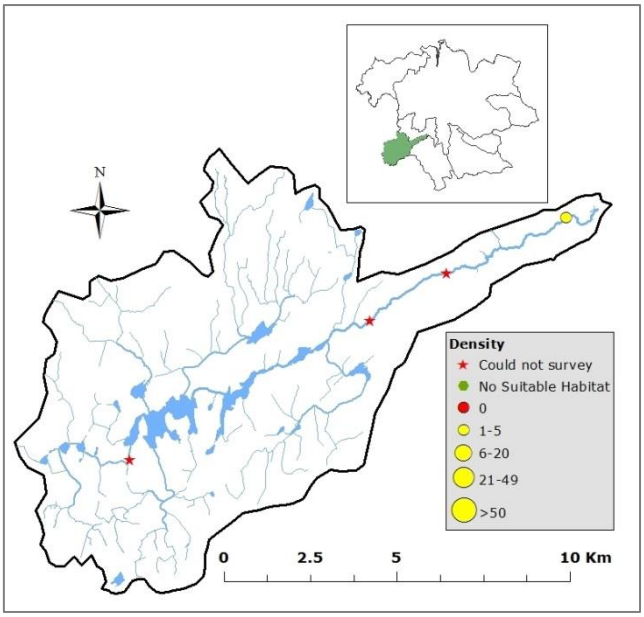


Figure 2.13. *Lampetra* spp. larvae results for the Castlebar sub-catchment in 2018.

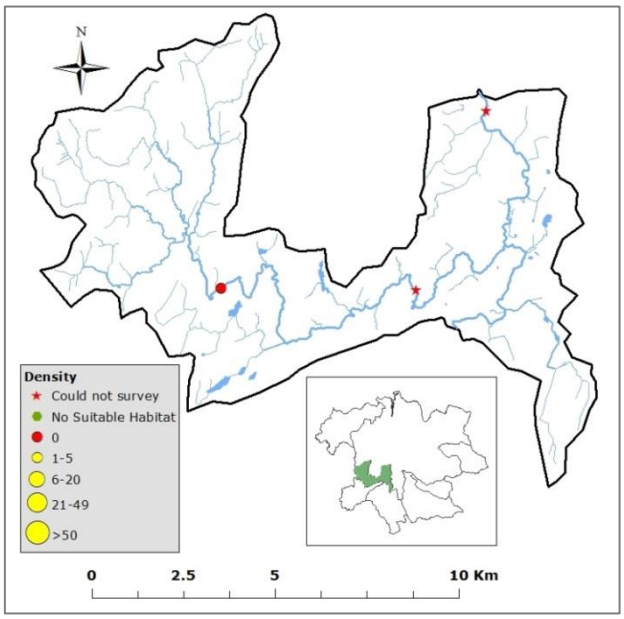


Figure 2.14. *Lampetra* spp. larvae results for the Clydagh sub-catchment in 2018.

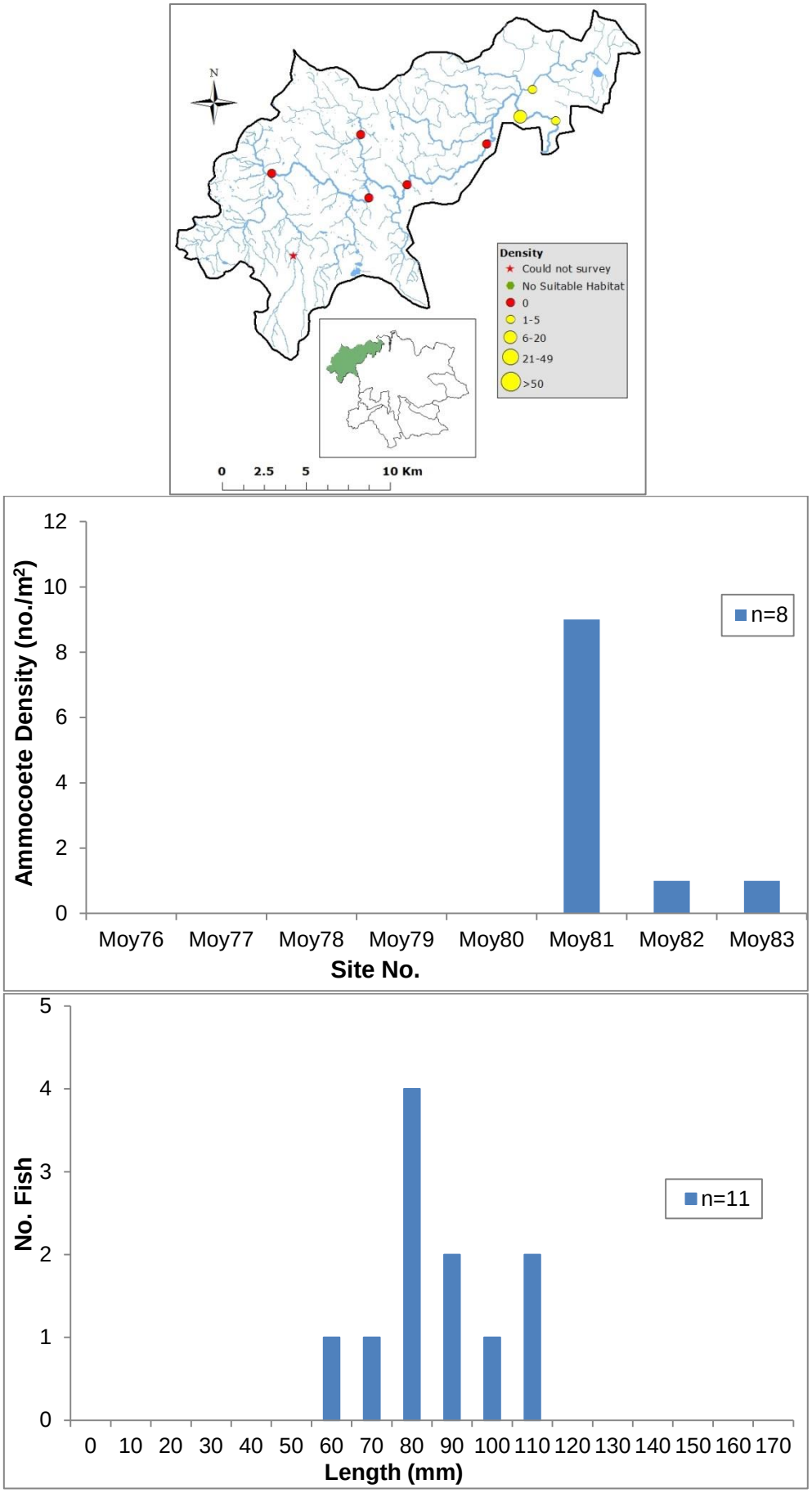


Figure 2.15. *Lampetra* spp. larvae results for the Deel sub-catchment in 2018.

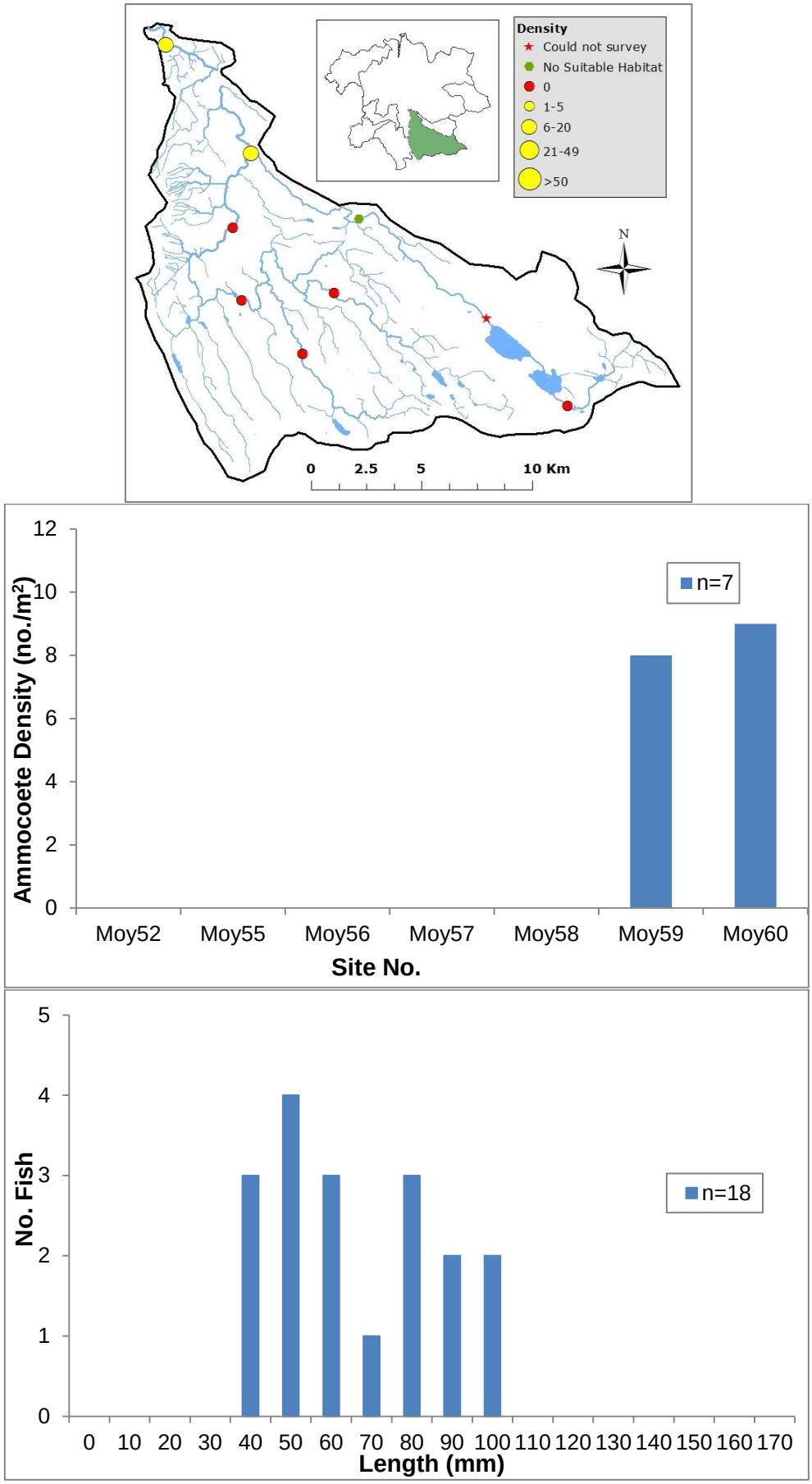


Figure 2.16. *Lampetra* spp. larvae results for the Gwestion sub-catchment in 2018.

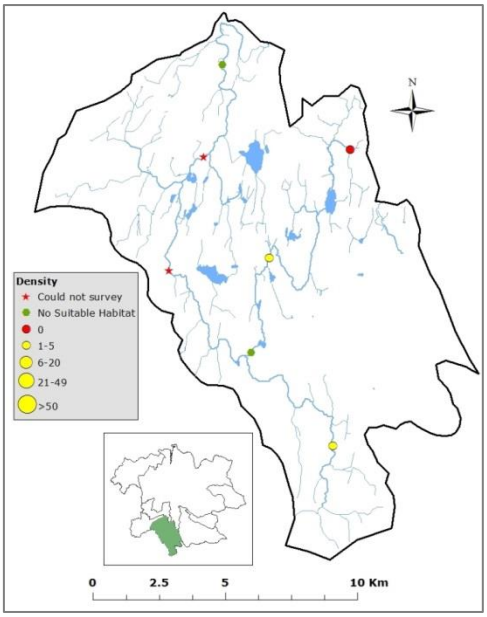


Figure 2.17. *Lampetra* spp. larvae results for the Manulla sub-catchment in 2018.

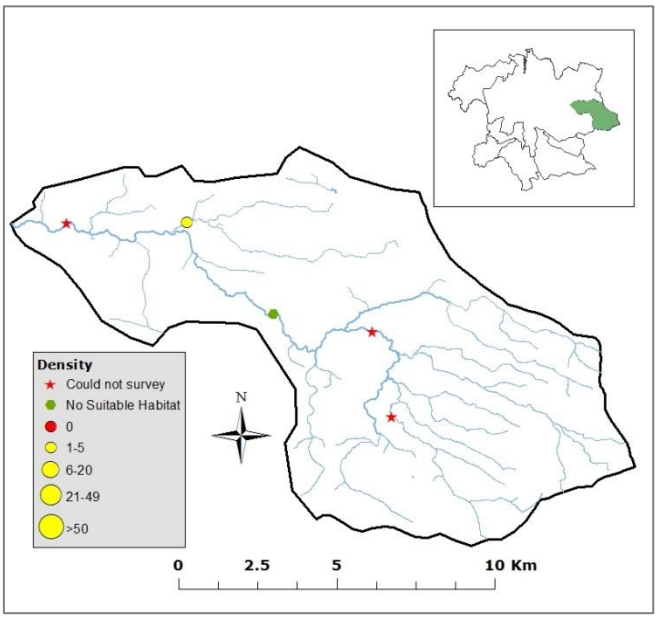


Figure 2.18. *Lampetra* spp. larvae results for the Owengarve sub-catchment in 2018.

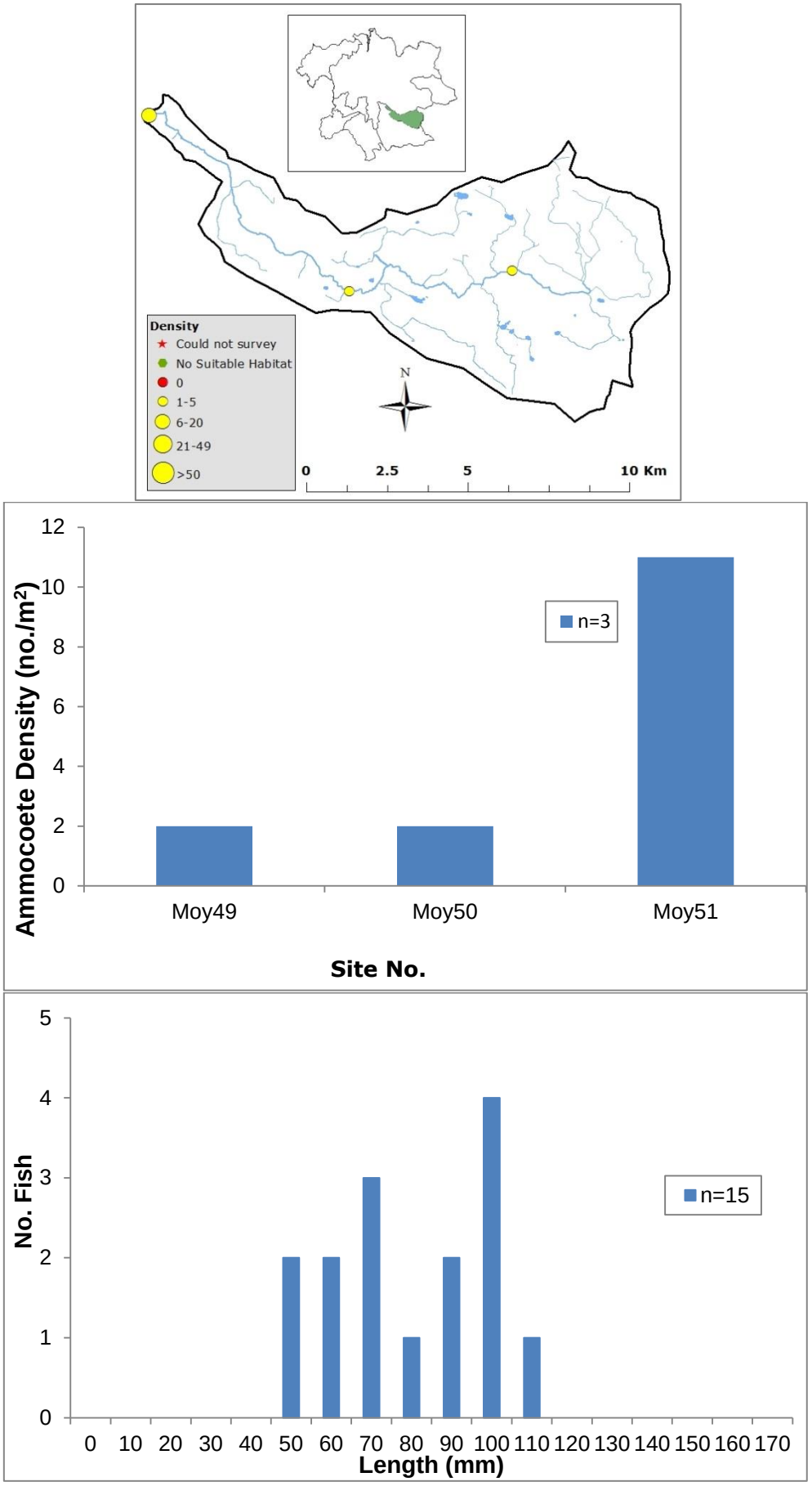


Figure 2.19. *Lampetra* spp. larvae results for the Trimoge sub-catchment in 2018.

A previous catchment-wide survey of the Moy was commissioned by the National Parks and Wildlife Service (NPWS) in 2004 (O'Connor, 2004). A total of 75 sites were electro-fished on that occasion, while a further 26 sites were visited but not sampled due to an absence of suitable habitat. Lampreys were present at 47 (63%) of the 75 sites, with *Lampetra* spp. accounting for 85% of the lampreys encountered by number. Unlike in the current survey, *P. marinus* larvae were also recorded at the time. These were generally confined to the Lower River Moy, but were also present in some of the tributaries, including the River Deel. Nominal numbers of larval *P. marinus* were also recorded in the Upper Moy catchment. Mean minimum densities of *P. marinus* and *Lampetra* spp. larvae were 0.1 ± 0.09/m^2 and 0.69 ± 0.32/m^2 respectively. The report stated that the significantly lower minimum densities in the Moy compared with those recorded for the Slaney and Munster Blackwater (King & Linnane, 2004) may reflect the poor and fragmented supporting habitats which occur in many areas of the Moy catchment – mainly as a result of the arterial drainage programme carried out in the1960s.

It is evident from the current survey that little has changed since the 2004 report in terms of *Lampetra* spp. larvae. Although 88% of sites were identified as having suitable nursery habitat, silt beds were frequently difficult to find at the individual site level and often amounted to only isolated pockets of suitable deposits. The apparent poor availability of nursery habitat throughout the catchment is likely to be a significant limiting factor. It should be stated that 10 sites in modified channels of the Owengarve, Gwestion, Castlebar and Clydagh sub-catchments could not be sampled because they were too deep. Given the depositional nature of these channels, it is likely that larval lampreys are present here but the electro-fishing method is not appropriate for sampling these deep, slow-moving reaches. Further work, involving different sampling techniques, would be needed to investigate lamprey populations in these heavily modified channels.

No larval lamprey data are available for the Moy catchment prior to the drainage works in the 1960s and, without knowing the status of lamprey populations before these operations, it is not possible to comment on whether the current unfavourable condition is due to poor recovery or poor colonisation post-works. Other factors associated with the Moy catchment, including topography, land cover, sediment supply etc., may be affecting lamprey recovery/colonisation but this is not known. A catchment-wide survey of the Boyne (another extensively drained system) in 2015 (Gallagher *et al*., 2016) found larval *Lampetra* spp. populations to be in favourable condition (with a mean density of 6/m^2 and with 72% of sites positive for *Lampetra* spp.). Investigations of other heavily modified catchments found that the River Maigue (mean density of 3/m^2 larvae) and River Boyle (mean density of 4/m^2

larvae) did not achieve favourable condition during surveys carried out in 2012 (Rooney *et. al*., 2013).

2.1.3 Larval Lamprey Reference Channels

Introduction

Article 17 reporting for Habitats Directive requires Member States to provide both current status of species (or habitats) as well as reporting on population trends and changes in geographic range covering an extended reporting period. In view of this, at the start of the 6-year reporting cycle for Article 17 (2013-2018), there was a need for IFI to appraise its surveying protocol to provide appropriate long-term data for time-series and trend analyses. It was believed that increasing the frequency of visits, annual or biennial, to a set of index channels would generate robust data regarding status, structure and trends of lamprey species populations, distribution range, quality and quantity of habitat available, potential pressures, threats and prospects for the future. A suite of index channels was therefore selected for the 2013-2018 EU reporting cycle to provide a broad geographic representation nationwide (Figure 2.20). Each channel contained 5-9 independent sites to be surveyed for lamprey larvae annually or in alternate years, with sampling locations to be in characteristic habitat type for larval lamprey.

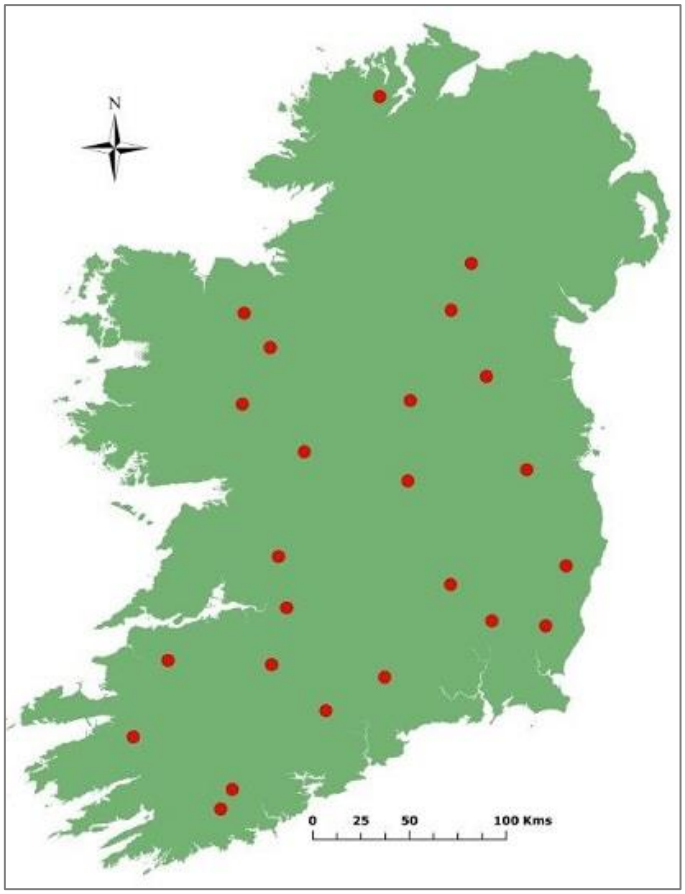


Figure 2.20. Locations of the larval lamprey index channels in use 2013-18.

Methodology

Study Sites and Population Counts

A total of 24 index channels were surveyed during the period 2013 to 2018 (Figure 2.20). Attempts were made to visit each channel at least every two years (biennially) with some sites visited annually, the exception being the River Inny which was visited on one occasion only. Supplementary survey data were available for several of the index channels where catchment-wide surveys, using the same sampling protocol, were undertaken during the period 2009 to 2012. The number of individual sites surveyed during visits to index channels varied from 2 to 10. Larval lamprey captures were pooled across sites to give an overall count for each index channel per visit. This measure was divided by the number of sites visited to give an average count which was used in all subsequent data analyses.

Plate 2.9. An index site on the River Leannan at Ramelton, Co. Donegal.

Statistical Analysis

All statistical analyses were undertaken using R (R Core Team, 2018). Localised population abundance over time for each index channel was examined (Mann Kendall test) to detect monotonic upward or downward trends. Count data across all locations were pooled to test for a larger scale trend. Locally weighted scatterplot smoothing (LOWESS) from the R base package was used to fit a trend line through a bivariate scatterplot of larval lamprey abundances over time. Temporal trends of larval lamprey abundance were further examined using generalised additive mixed models or 'GAMMs'.

Plate 2.10. Processing ammocoetes on the Dripsey River, a tributary of the Lee, Co. Cork.

Results

Individual plots of larval lamprey abundance were produced for each of the 24 index channels (Figure 2.21). Fluctuations in numbers were noted between consecutive surveys for many of the channels.

For index channels visited annually (n=12), typically in SACs where 5-6 years of consecutive survey results were available (Figure 2.22), population count data allowed for rudimentary statistical trend analysis. These channels included the Barrow (Mountain River), Boyne (Kells Blackwater), Erne (Annalee), Feale, Liffey, Monaghan Blackwater, Moy, Mulkear, Munster Blackwater, Nore (Dinin), Slaney (Bann) and Suir rivers. While fluctuations in numbers were apparent during the study period for several of the channels, no significant upward or downward population trends were identified following statistical analysis (Mann Kendall test for trend), inferring that populations remained relatively stable during the period.

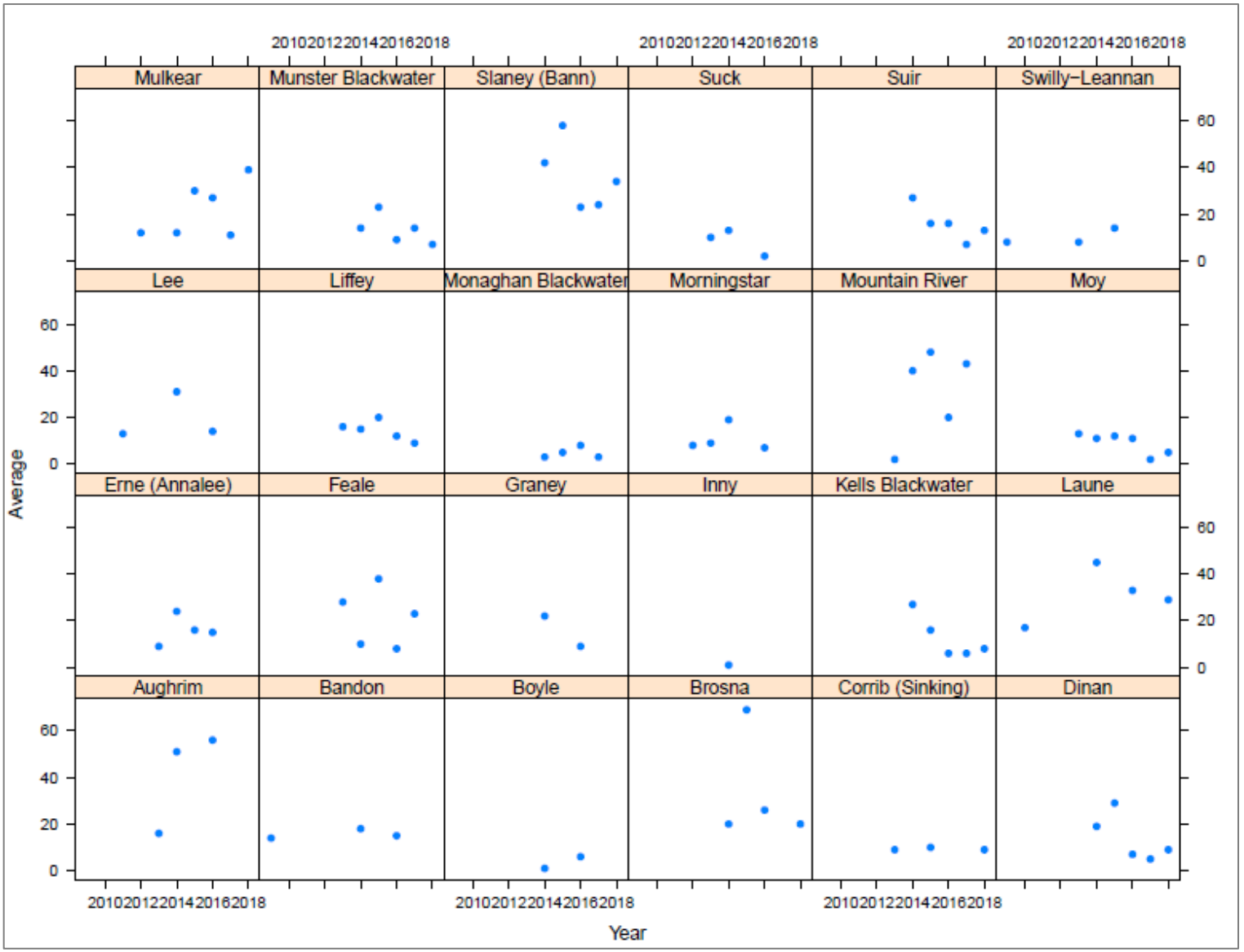


Figure 2.21. Individual larval lamprey abundances for all 24 index channels as recorded over the period 2013-2018.

Plate 2.11. The River Dinin at Jenkinstown Wood, Co. Kilkenny.

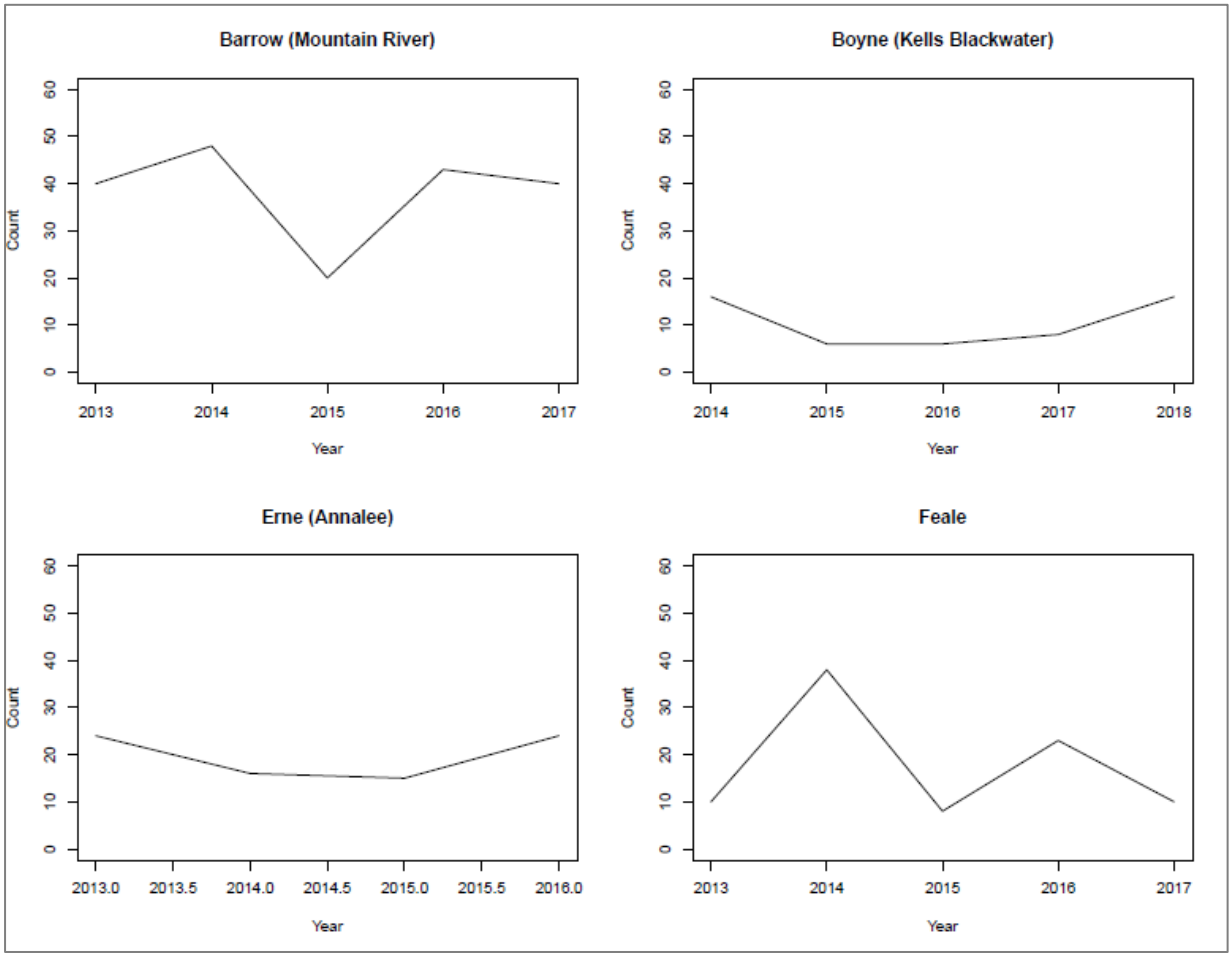


Figure 2.22. Population abundances of larval lamprey on annually surveyed index channels (n=12) during 2013-2018.

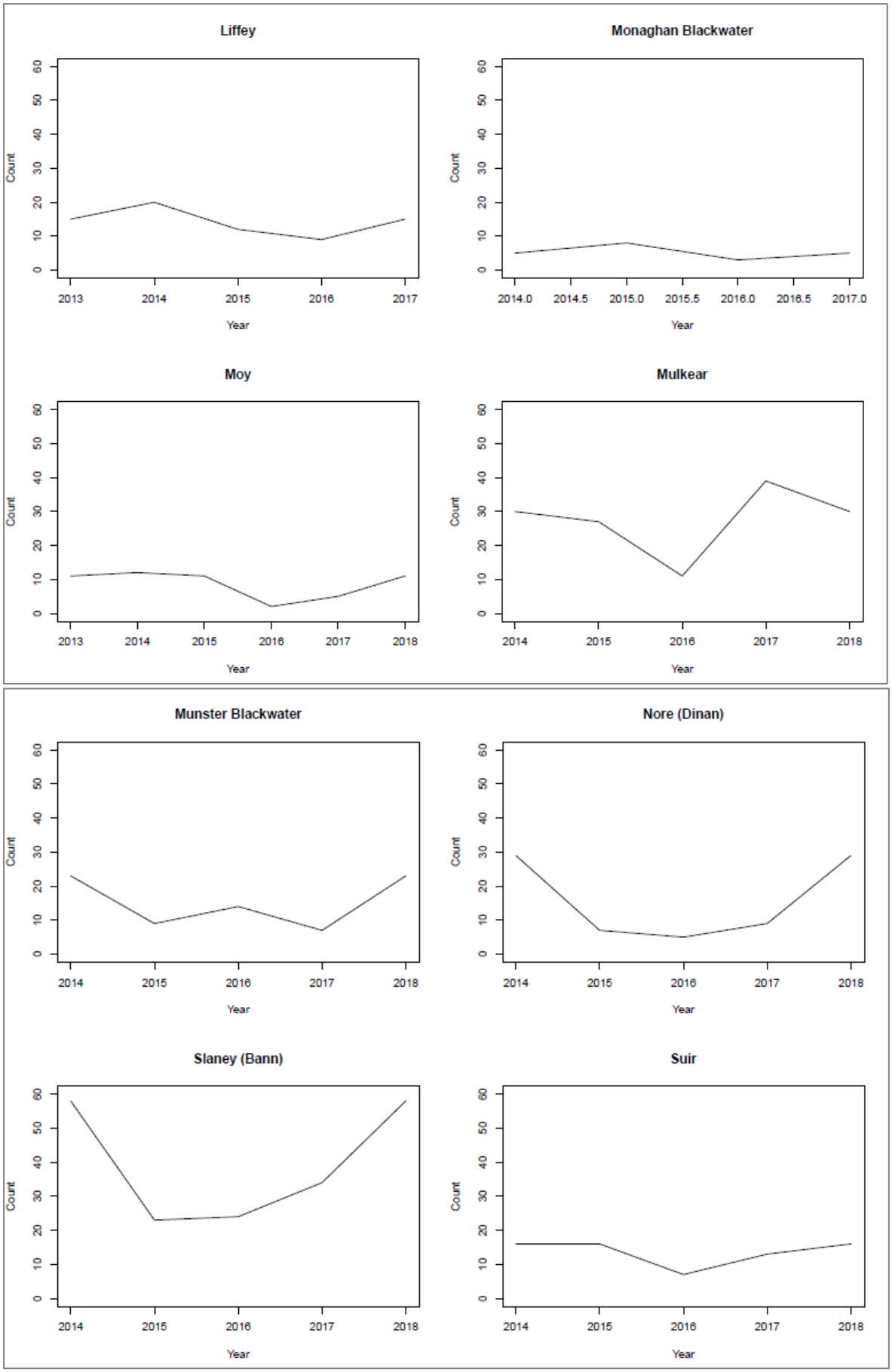


Figure 2.22. continued.

When all survey counts (n=95) for all reference channels were pooled and plotted (Figure 2.23), a LOWESS locally smoothed trendline indicated a slight countrywide increase in numbers during 2013 to 2015 followed by a gentle decrease to previous levels.

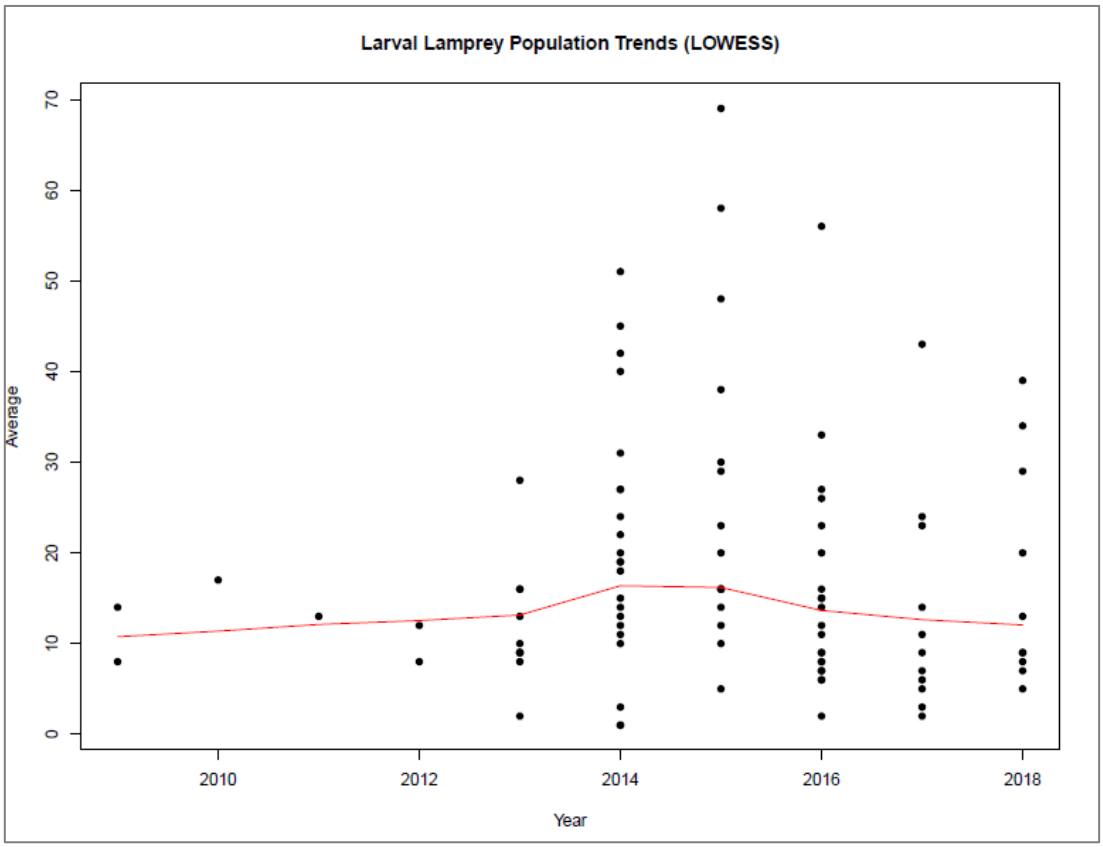


Figure 2.23 Larval lamprey abundance across 24 sites surveyed mainly from 2003 to 2018. A LOWESS smoothed trendline (red) has been added to the data.

Further analysis of the data, using modelling packages available in R, generated a smoothed trendline that describes the underlying data well, as evidenced by the fitted values (Figure 2.24). The temporary upward trend during the period 2013-2015 as inferred by the earlier LOWESS smoothed trendline (Figure 2.23) is accentuated and extended to 2016 by the GAMM model. The initial gradual rise from 2012 to 2014 may be attributed to the commencement of surveying along index channels and the inclusion of more sites and therefore more varied count data. The dip in 2017 may be due to increased river water levels during that summer and autumn. Consequently, conditions for electro-fish surveying were difficult and sampling effort was compromised, resulting in fewer larvae encountered in some channels.

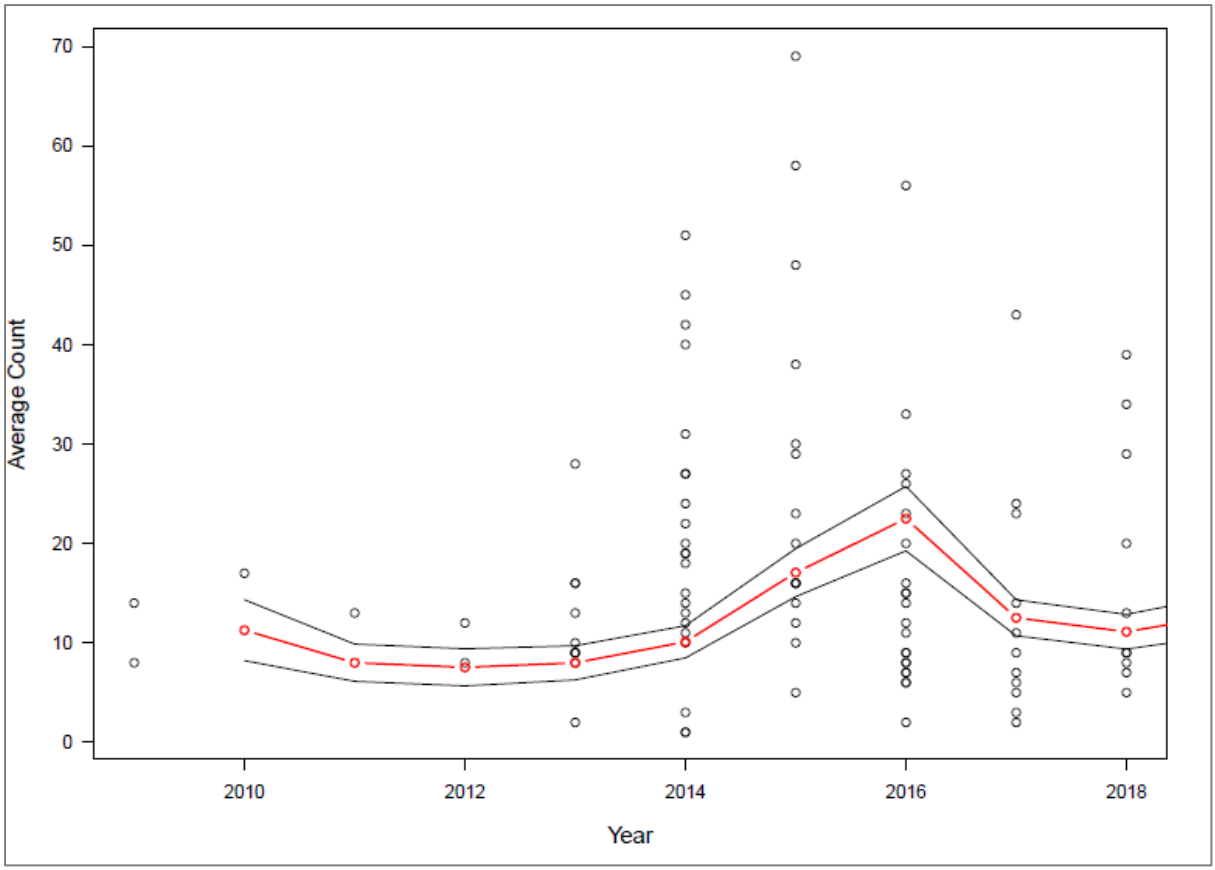


Figure 2.24. Trends in larval lamprey abundance as predicted by a GAMM. Mean abundance is indicated by the red line with thin lines indicating 95% confidence intervals.

Plate 2.12. The Bandon River at Ballineen, Co. Cork

Discussion

Results from the initial 6-year period of the larval lamprey reference channel survey programme has categorised the presence of favourable populations of river/brook lamprey ammocoetes nationwide. No monotonic upward or downward trends were identified, and hence populations are deemed stable. Variations in local abundances between surveys were noted at most locations. Over time, however, these variations do not contribute to any trend aside from population stability during the period in question.

Sampling locations and protocols will be subject to review and appraisal following each reporting cycle to identify and reduce potential sources of bias, e.g. spatial dependence, and to increase the robustness of the overall methodology and the resultant data. Issues such as sample sizes, surveying effort and intensity and a requirement to provide representative coverage of the variety of habitat types available for larvae within channels/catchments are important ongoing considerations. For this initial period of survey, data analysis focussed entirely on larval abundance (counts). The influence of other potentially important environmental variables such as water temperature, river levels, summer floods, changes in land use, pollution events, etc., was largely ignored in this preliminary investigation. Inclusion of predictor variables, as well as potential interactions, represents the next logical step in this monitoring study.

Plate 2.13. The Beheenagh River at Barraduff, an index site on the Laune, Co. Kerry

Assessment of population trend information is central to Article 17 reporting, since only stable or increasing trends can inform 'Favourable' conservation status (EC DG Environment, 2017). It was recommended that more attention be paid to the methodology of monitoring schemes to provide suitable data from the outset and to improve the quality of trend information. Through regular repeat surveying, the larval lamprey reference channel survey programme instigated by IFI in 2013 has initiated a framework towards a rigorous, consistent and dedicated monitoring scheme. Data gathered from this programme can be used to identify short-term trends (over 2 reporting cycles) and longer-term trends (4+ reporting cycles) required to detect real changes.

2.2 Adult lamprey investigations

As in the previous year, adult lamprey investigations in 2018 focused on *Petromyzon marinus*. The principal elements involved were broadly similar to those employed previously, i.e.

- Float over (walk over) surveys of selected main stem SAC rivers to identify locations of sea lamprey spawning and to enumerate spawning effort
- 'Hot spot' surveys at selected, localised sites of known sea lamprey spawning activity – with the aim of compiling an annual programme of such visits permitting an examination of annual effort and how this may vary over time
- Survey programme of large barriers on main stem SAC Rivers that might impede upstream migration for sea lamprey. As previously, the SNIFFER or WFDIII sampling protocol was used to survey a series of structures
- Investigations on so-called 'land-locked' sea lamprey found in certain Irish lakes

2.2.1 Walk-over survey Deel (Moy catchment)

The River Deel is a major sub-catchment in the Moy system and discharges into the northern end of Lough Conn. Its tributary sources rise in the Nephin Mountain area and flow in a generally easterly direction to Lough Conn. The system is well-supplied with alluvial material from the headwaters and extensive areas of gravel and cobble are known to occur in areas of the river. The river is part of the River Moy SAC (Site Code: 002298) with designations for Atlantic salmon, otter, freshwater crayfish and two of the three lamprey species recorded in Ireland – brook and sea lamprey. Populations of freshwater pearl mussel are also recorded from the River Deel. There are anecdotal records of sea lamprey in the Deel (Kurz and Costello, 1999).

Float-over surveys are used as a sampling technique by IFI to estimate sea lamprey spawning activity on the main stems of Irish SAC rivers. They are carried out in a short timeframe, generally in July, towards the end, or after, the spawning period (May/June) in an effort to accurately quantify the extent of spawning in a given year. Sections of the River Moy main stem were examined in 2011 and 2017 *via* float-over survey technique and it was proposed to use sit-on kayaks again in 2018 to explore the River Deel for evidence of sea lamprey spawning activity and of suitable spawning habitat for the species.

The drought conditions that prevailed in Ireland during the summer of 2018 led to low water levels in the River Deel. This was particularly pronounced in the areas of karst limestone, over which this river flows, adjacent to and downstream of Crossmolina town and downstream to Lough Conn. Given these conditions, the channel was inspected over extended segments by walking of the bank. It was planned that records would be compiled, *via* GPS instrument, of locations of sea lamprey spawning, of potential barriers to migration – natural and man-made – and of areas of suitable spawning habitat. Walk-over surveying was undertaken on 28-29th June 2018 (Figure 2.25).

The channel was walked continuously from a fording point upstream of Crossmolina to the most downstream road bridge at Deel castle (11.2 km), prior to the river discharging to Lough Conn. Much of the river was dried out or 75% dried out and there was no evidence of any redd construction by sea lamprey. Those areas containing suitable spawning habitat, in terms of river bed gradient and bed particle size, were geo-referenced. Locations of man-made or natural barriers to fish migration, in normal summer flow conditions, were also geo-referenced. The ford crossing appears likely to be an issue for both up- and downstream migrating fish of all species due to the constricted flow through culvert pipes and the elevated velocities generated. In addition, there are two sections of bedrock geology that intrude directly and form the channel bed. These present as a series of step – pools with some resting areas and some high velocity and hydraulic head issues (Plate 2.15).

From the ford upstream of Crossmolina, the channel upstream was fully watered, for summer flow conditions. In all, 4.5 km of river sections was walked from the aforementioned fording point upstream as far as Ballymoneen. There was no evidence of sea lamprey spawning in the areas examined.

The overall survey on the River Deel identified the presence of substantial areas with habitat type that would be suitable for spawning sea lamprey.

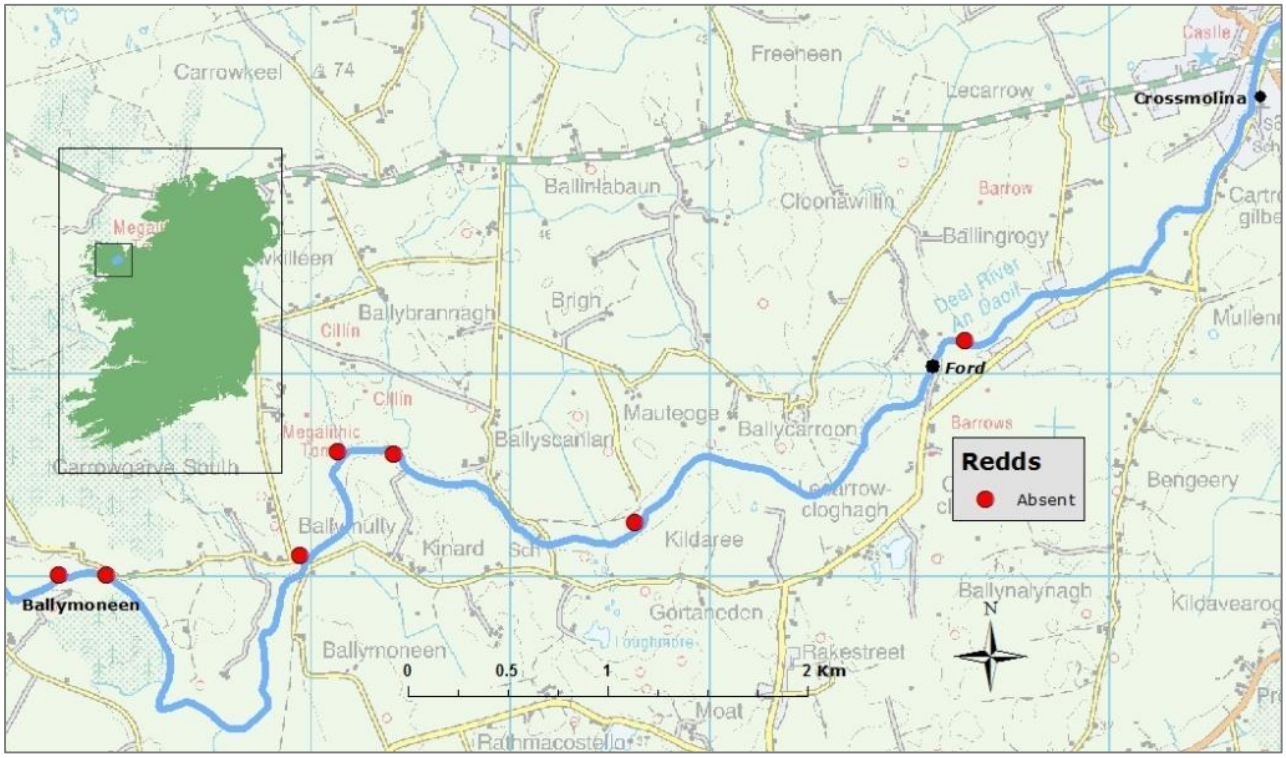


Figure 2.25. Map to show (a) the extent of channel inspection and (b) the up- and downstream extent of sea lamprey spawning habitat identified.

Plate 2.14. Characteristic bed material in River Deel, suitable for spawning sea lamprey.

Plate 2.15. Stepped bedrock area in River Deel: spawning sea lamprey need to negotiate this area to reach upstream graveled areas.

Plate 2.16. Location with potential sea lamprey spawning habitat in upper catchment of River Deel.

Plate 2.17. River Deel downstream of Crossmolina, almost-dry river bed, June 2018.

2.2.2 Walk-over survey Feale

This survey was undertaken over three days (26th-28th) in June 2018, retracing and expanding on a similar survey undertaken in July 2014. Significant barriers to upstream migration exist in the lower reaches of the Feale, namely Scartleigh weir for municipal water extraction 4km downstream of Listowel, the footings of a pedestrian bridge in Listowel town centre, providing access to the adjacent race-course, as well as several sections of high gradient rapids with exposed bedrock cascades (Figure 2.26).

Surveying commenced in the upper catchment at Wellesley Bridge between Abbeyfeale and Mountcollins, Co. Limerick, a single redd was observed immediately downstream of this access point (Figure 2.26). Surveying continued downstream of this location at the confluence of the Feale with the Owbeg River. A section of this significant tributary river was surveyed upstream of where sea lamprey ammocoetes were previously recorded at Bateman's Bridge (O'Connor, 2006). No evidence of spawning activity was noted at this upper section of the catchment or further downstream in the environs of Abbeyfeale town, where a stretch of suitable spawning habitat exists 1km upstream of the Listowel Road Bridge (Figure 2.26).

Plate 2.18. Recording characteristics of a sea lamprey redd on the River Feale at Wellesley Bridge, Co. Limerick.

The next convenient access point is 6.5km downstream of Abbeyfeale at Duagh Bridge, where 2 sea lamprey redds were recorded in 2014. Thorough surveying 1km upstream and downstream of this location failed to locate nests on this occasion. Access is available at a further 3 locations between Duagh Bridge and Listowel Bridge *via* designated angler parking, stiles and paths. A single redd was noted in 2014 at one of these angling stretches below the confluence of the Smearlagh River. Repeat surveying along this section in 2018 revealed a cluster of 6 redds in precisely the same location (Figure 2.26).

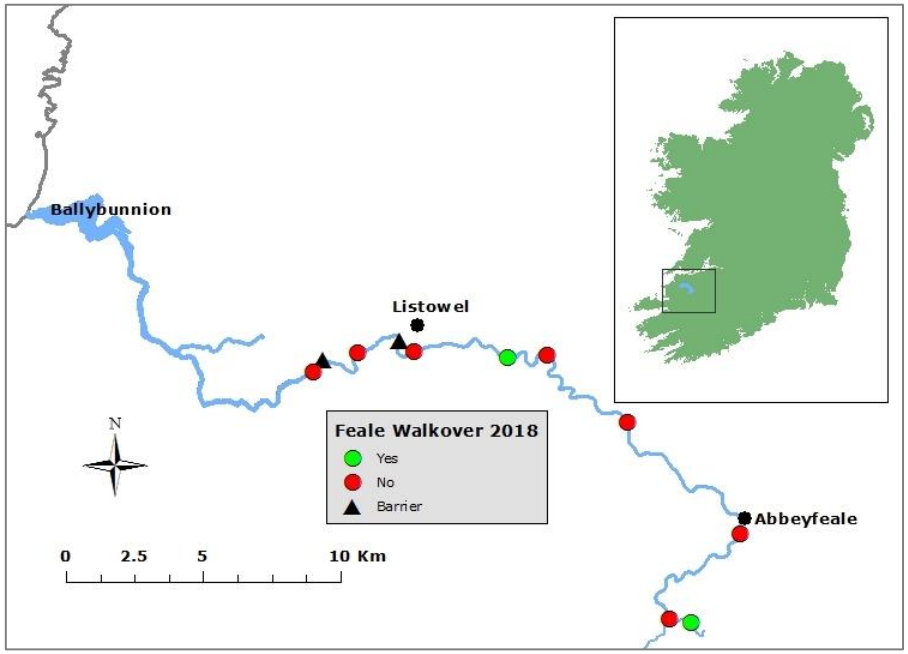


Figure 2.26. Locations of survey sites, barriers and confirmed sea lamprey spawning activity on the River Feale during 2018.

Plate 2.19. The River Feale between Listowel town and Scartleigh weir.

Further downstream, searches through sections of suitable spawning habitat in Listowel town, downstream of the racecourse and in the upper tidal limits above Finuge Bridge yielded no more redds (Figure 2.26). In summary, walkover surveying along selected sections of the River Feale confirmed successful passage of sea lamprey through the Scartleigh weir fish pass, followed by upstream migration during relatively low flow conditions during May and early June (Figure 2.27).

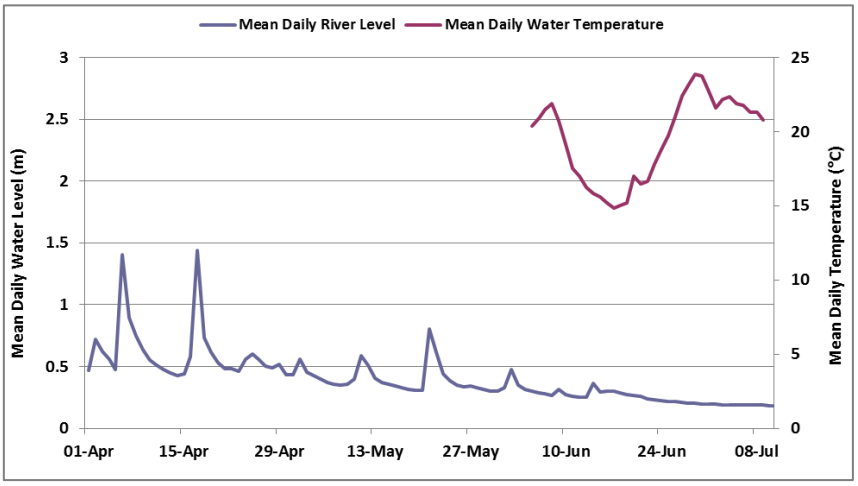


Figure 2.27. River Feale levels and water temperatures measured at Listowel Bridge (OPW hydrometric gauging station #23002) during the 2018 sea lamprey migration and spawning period.

2.2.3 Hotspot Surveys

As with previous years, a selection of sea lamprey spawning 'hot-spots' were visited during 2018 in order to ascertain timing, extent and annual consistency of breeding effort (Table 2.3). Hot-spots comprise traditionally renowned spawning sites on individual SAC rivers

across the south and south east as well as within the Lower Shannon SAC (Figure 2.28).

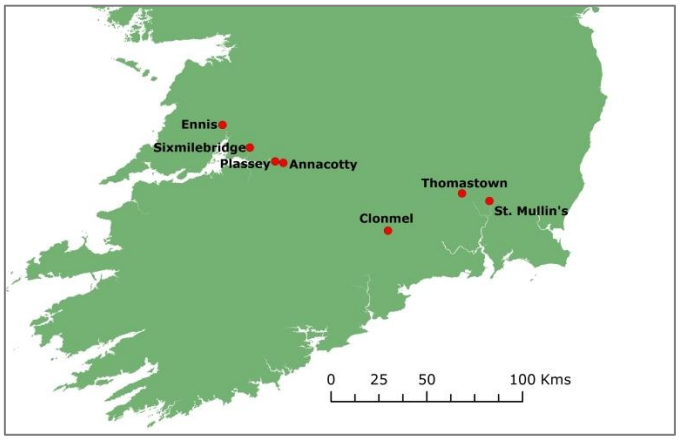


Figure 2.28. Location of principal sea lamprey spawning 'hot-spots' surveyed annually.

For the River Fergus in Ennis Town, regularly updated records of sea lamprey presence and spawning activity during 2018 were again provided by a highly regarded local amateur naturalist. Adult fish were noted from May 31st until June 21st excavating nests in the section from Club Bridge along Newbridge Road/Steele's Rock towards the Court House. The locally-based observer noted that there were fewer fish overall than previous years. Activity ceased completely after June 21st.

The Mulkear River at Annacotty, Co. Limerick was visited in late May and twice in June 2018. A 150m section, consistent with previous years, extending 100m downstream and 50m upstream of the old Annacotty bridge, was thoroughly searched, with counts compiled of all adult sea lamprey and redds encountered (Table 2.3). The first visit (May 25th) confirmed the presence of sea lamprey (n=4) and nests (n=8). The 2nd visit (June 6th) encountered 29 adult fish and 76 nests. The final visit (June 15th) encountered extensive nest-building, frequently compound in nature and impossible to accurately count.

Plate 2.20. The annually surveyed hot-spot section on the Mulkear River at Annacotty, Co. Limerick.

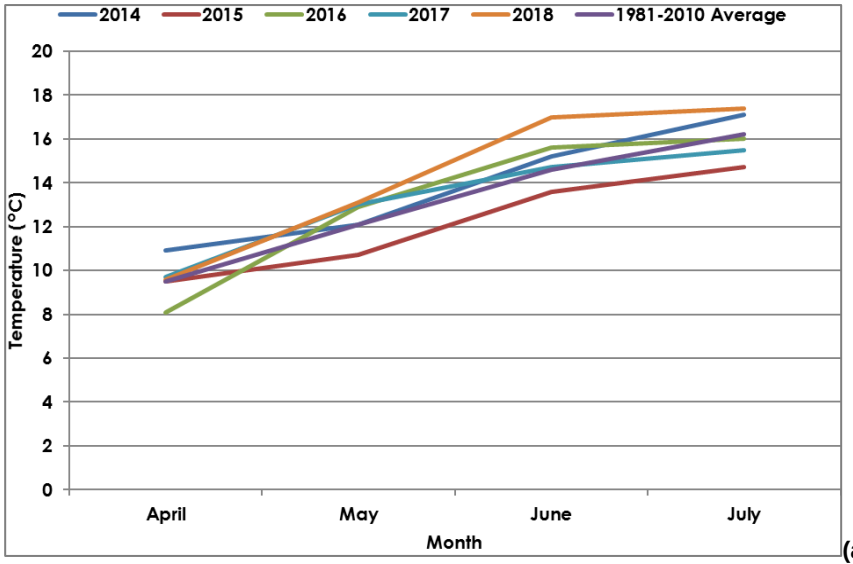
In addition to surveying the annual hot-spot section on the Mulkear River immediately downstream of Annacotty Weir, several traditional spawning locations on upstream tributaries were visited in order to appraise the continuing efficacy of fish passage structures incorporated into the barrier. Sea lamprey redds were noted on the Mulkear River at Scart (n=8) immediately downstream of the confluence of the Mulkear and Killeenagarriff rivers, as well as further upstream on the Killeenagarriff itself (n=4). No redds were found during searches further upstream at locations along the Newport and Bilboa rivers. A noted spawning location on the latter river upstream of Cappamore had no redds in 2018 due to incursion and disturbance by cattle seeking shelter from the sun and to access drinking water. Nevertheless, the presence of nests at a variety of locations in the mid/upper catchment implies some degree of successful ascent of Annacotty Weir followed by onward progression into the interior of the system.

Table 2.3. Sea lamprey spawning activity across annually visited 'hot-spots' during 2018.

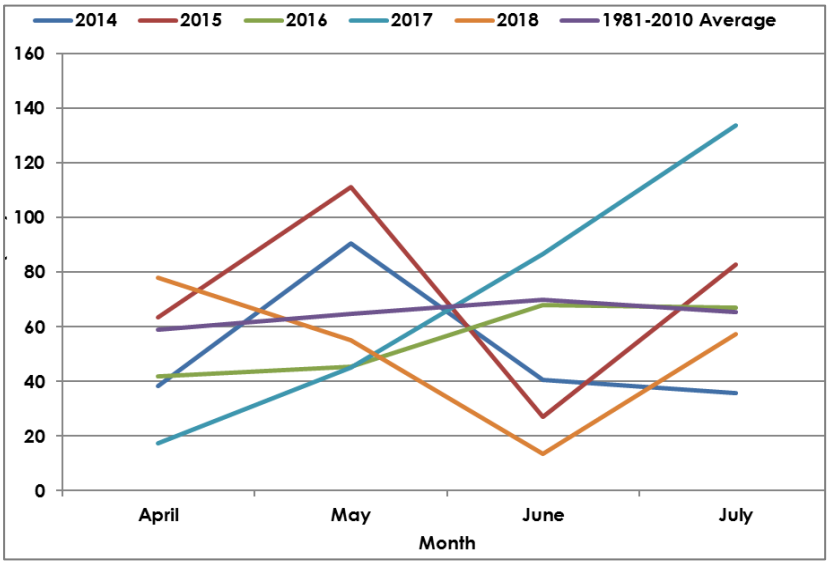
Date	Location	Sea Lamprey	Redds	Temp (°C)
31/05/2018 to 21/06/2018	River Fergus, Ennis Town, Co. Clare	Present	Present	NA
25/05/2018 06/06/2018	Mulkear River, Annacotty, Co. Limerick	4 29	8 76	15.7 19.7
25/05/2018 15/06/2018	River Shannon, UL Living Bridge, Plassey, Co. Limerick	3 0	1 10	NA 17.7
25/06/2018	River Suir, Clonmel, Co. Tipperary	0	5	NA
30/05/2018 to 21/06/2018	River Nore, Thomastown, Co. Kilkenny	1	5	16.7 to 17.9
30/05/2018	River Barrow, St. Mullins, Co. Carlow	1	2	NA

Plate 2.21. Sea lamprey nests on the River Shannon, Plassey, Co. Clare.

Nest building was recorded at other hot-spots such as the River Barrow below St. Mullins Weir, the Nore at Thomastown, the Suir at Clonmel and the River Shannon in the grounds of University of Limerick (UL) at Plassey. Overall, observations for 2018 were similar to previous years, with adult fish recorded excavating redds from late May to mid-June. An extended dry and warm spell resulted in low river levels and moderate to high water temperatures (15.7 to 19.7°C). Air temperatures were above average for the spawning period (Figure 2.29a), whilst rainfall amounts were much lower than expected (Figure 2.29b). Meteorological data were obtained from a weather station at Shannon Airport, Co. Clare, the data from which should be broadly representative of the Lower Shannon area where the majority of sea lamprey spawning hot-spots are located.



(a)



(b)

Figure 2.29. Monthly mean air temperatures (a) and total rainfall (mm) (b) from April to July over consecutive years (2014 - 2018) recorded at Shannon Airport (Met Eireann) in comparison with the 30 year (1981-2010) long-term average (LTA).

2.2.4 Drone Surveying as a tool for investigation spawning sea lamprey

In 2018 a drone was used to trial the value of aerial reconnaissance for sea lamprey spawning at some well-known locations. The drone was trialled at Clonmel (River Suir), Inistioge (River Nore) and St. Mullins (River Barrow). During the surveys no redds were identified at Clonmel or Inistioge. A redd was visible at St. Mullins from the drone footage (Figure 2.30).

(a)

(b)

Figure 2.30. Drone footage of redd at St. Mullins with staff member on RHS (a), sea lamprey in the photographed redd (b), 31st May, 2018.

As the drone was initially being trialled in 2018 as a method of sea lamprey redd monitoring the success of the survey was limited. It is proposed to expand the areas which will be surveyed in 2019 and to undertake repeat flights at known sea lamprey spawning locations. Monitoring will continue on those areas surveyed in 2018 and expand to other locations. Given the implications and associated privacy afforded by the implementation of GDPR, consideration needs to be taken into account as to where monitoring can be undertaken using the drone.

2.2.5 Fyke Netting of the Avoca Estuary

The Avoca estuary was surveyed as part of IFI's WFD monitoring of fish stocks in transitional waters. A multi-method approach is taken in these surveys, involving beach seine netting, fyke netting and beam trawling.

Fyke netting of the Avoca estuary was carried out between the 18th and 20th September, 2018. Fyke nets (15m in length with a 0.8m diameter front hoop, joined by an 8m leader with a 10mm square mesh) are used to sample benthic fish in the littoral areas. All nets are processed on-site by identifying the species present, counting the total numbers caught and by taking a representative number of length measurements for each species. A total of 10 adult river lampreys were captured in 4 fyke nets (Figure 2.31) and these ranged in length from 28 – 34 cm. The Avoca catchment is not an SAC for river lamprey but adult river lampreys have been captured previously (Gallagher *et al*., 2017) and spawning locations for this species have been identified on the Rivers Aughrim and Avonbeg.

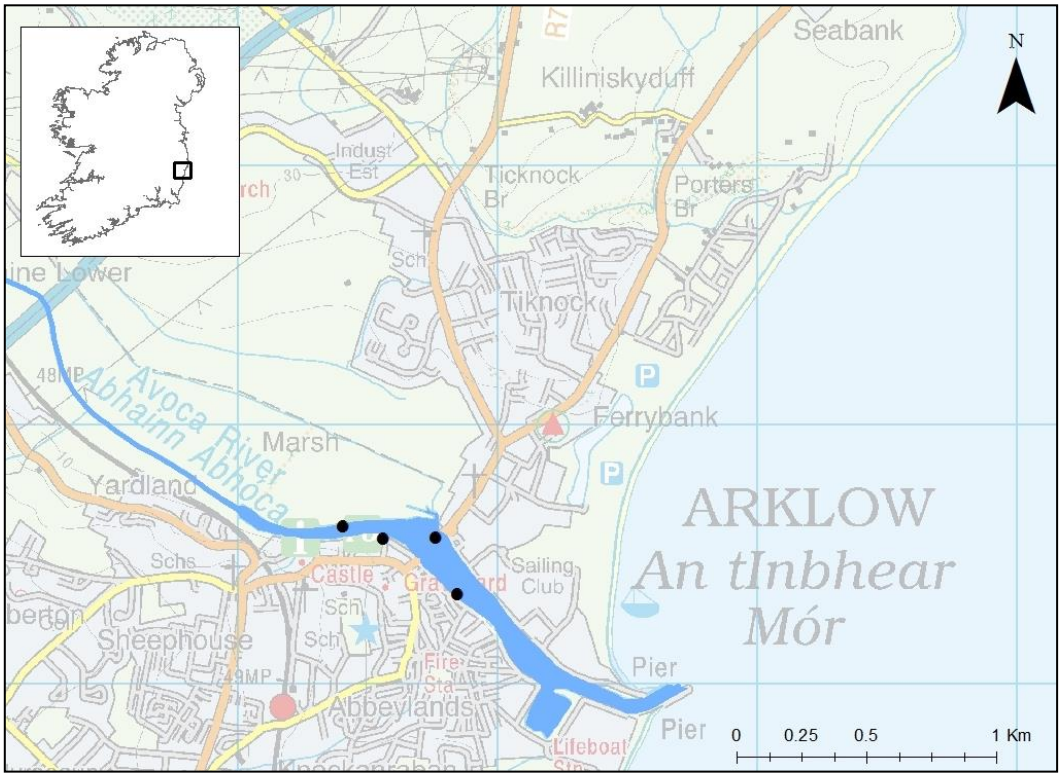


Figure 2.31. Fyke net locations for adult river lampreys in the Avoca estuary, September 2018.

2.2.6 Use of eDNA to investigate spawning sea lamprey

In order to broaden the knowledge of shad and sea lamprey distribution the possibility of detecting environmental (e)DNA in the water column was investigated. As an animal passes through an environment they can shed bodily material or products in the form of mucus, skin,

faeces, gametes or, potentially, a whole carcass. This material holds the DNA of the host organism and so by sampling water in which they are likely to have passed through, it is possible to identify if a target species has been present in a waterbody. eDNA can be used to detect the presence of a target organism without invasive sampling techniques, via quantitative PCR (qPCR) analysis (Gustavsson *et al.,* 2015). A recent eDNA study in Lake Windermere captured evidence of 14 of the 16 fish species known to inhabit the lake. Simultaneously a lake netting survey was undertaken on Lake Windermere which identified four of the fish species present (Hänfling *et al*., 2016). Inland Fisheries Ireland (IFI) supported initial trials by National University of Ireland (Dublin) to detect sea lamprey presence or absence in the context of the weir at Annacotty on the Mulkear (Gustavsson *et al*. 2015). Further, more extensive studies investigating sea lamprey presence and status using eDNA were undertaken on the Mulkear and Munster Blackwater by NUI(Dublin) working with IFI with very positive and promising outcomes (Bracken *et al*. 2019).

The success of the IFI/NUI(Dublin) studies on sea lamprey eDNA provides a sound platform to undertake further catchment-wide investigations on this species using this procedure. This is particularly pertinent in systems where little if any prior knowledge is available and provision of resources for extended walk-over or float-over surveys is challenging. The Habitats team also decided to broaden horizons and investigate the distribution of shad *via* eDNA (see Section 3.4).

2.2.7. River lamprey - survey outcomes from the Maigue catchment

In 2017 an elver trap was installed by IFI at the side of a crump weir on the River Maigue in the grounds of Adare Manor, Co. Limerick (Plate 2.31). The trap was checked every 2-4 days during April and May, and in addition to elvers a total of 10 adult river lamprey were also captured during this period (Plate 2.32). The maximum number encountered during a single visit was 3 individuals. No significant rainfall events occurred during this period and river levels were typically <0.5m at a nearby OPW gauging station. The elver trap was operated and monitored in a similar fashion during 2018. From late March to late April a total of 345 adult river lamprey were captured, including a haul of 234 individuals on April 10th. Supplementary information concerning river levels, tidal cycle in the downstream estuary, moon phase, rainfall and water temperature were gathered from various sources (OPW, Met Eireann, etc.). The major peaks in river lamprey migration during April 2018 (Figure 2.32a) occurred across various tidal conditions (measured at Ferry Bridge on the lower tidal Maigue), increasing water temperature and recent elevated river level recorded 1.5km upstream at Castleroberts (Figure 2.32b), following rainfall events in the catchment (Figure 2.32c) measured at Mount Russell, Co. Limerick. The corresponding lunar phase was a full

disc waning to a new moon. A single adult river lamprey was also captured in a similar trap operated on the River Feale at Scartleigh weir, Listowel, Co. Kerry on April 23rd 2018.

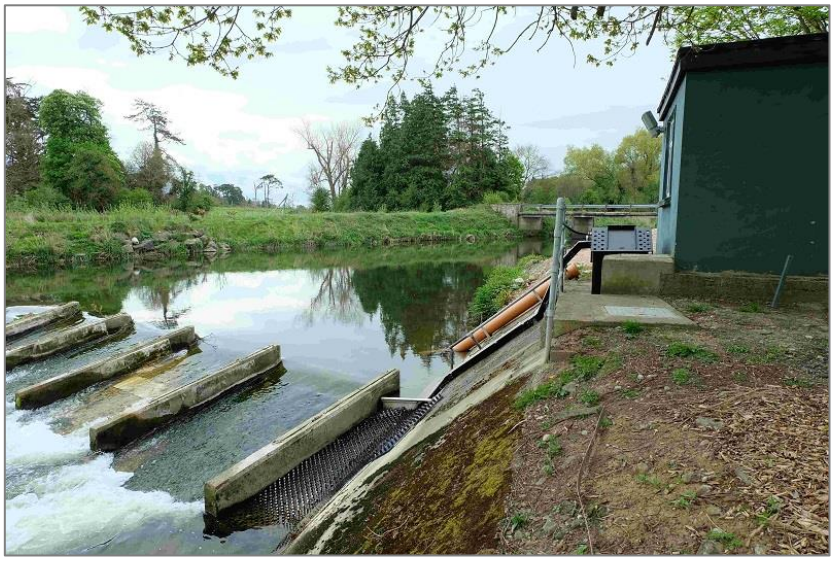
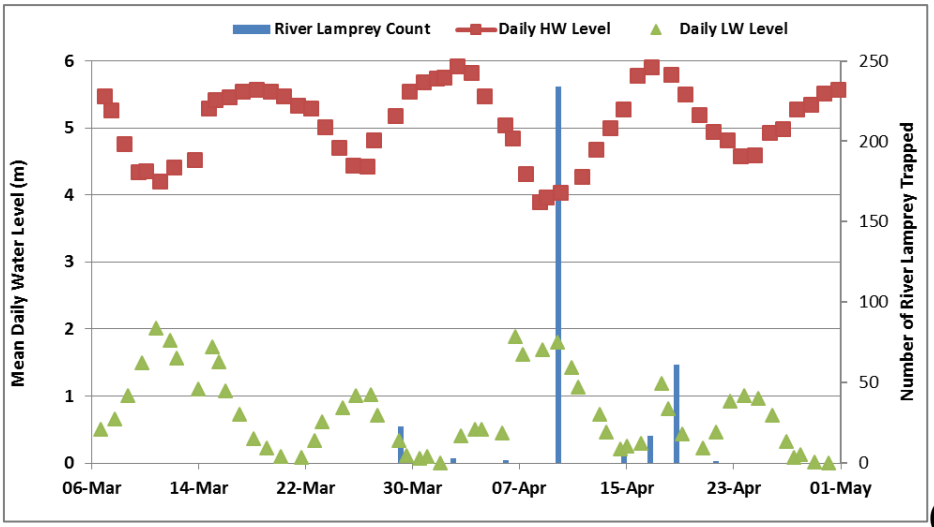
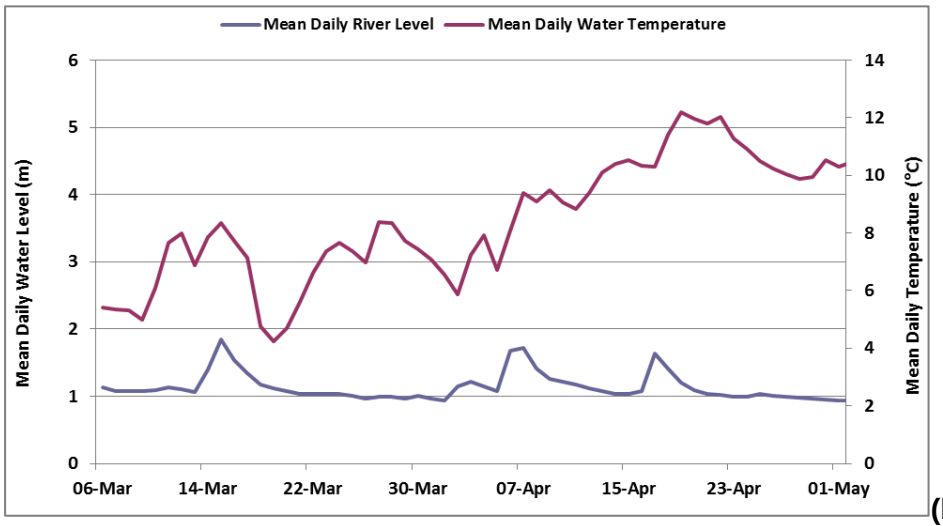


Plate 2.22. The elver trap on the River Maigue in the grounds of Adare Manor, Co. Limerick.

Plate 2.23. An adult river lamprey captured in the Adare Manor elver trap on April 17th2018.



(a)



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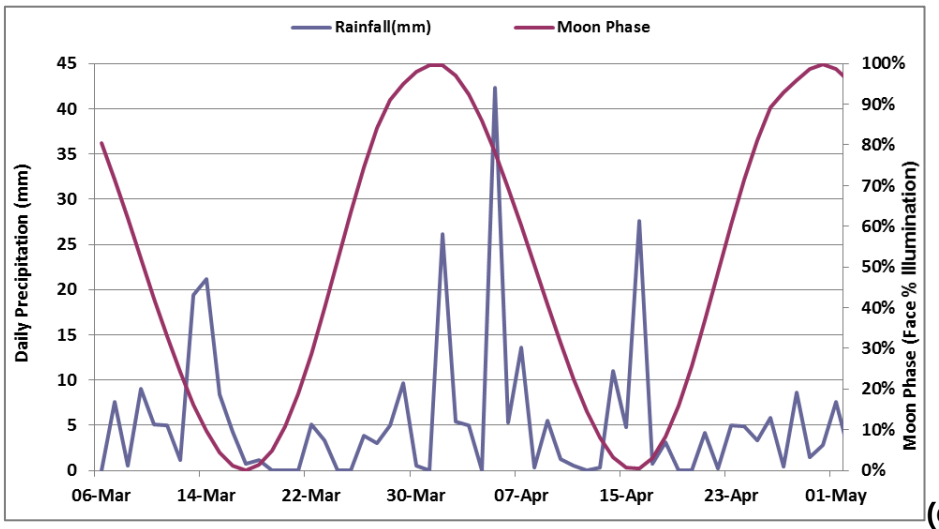

(c)

Figure 2.32. Incidence of river lamprey capture (a) in relation to corresponding environmental conditions, namely tidal cycle (a), river water temperature and level (b), rainfall and lunar phase(c).

3. Shad Programme

3.1 Juvenile Shad Investigations

3.1.1 Kick sampling for shad eggs

The Common Standards Monitoring guidelines for freshwater fauna (JNCC, 2015) advocates kick sampling for shad eggs as a way of determining the spatial extent of twaite shad (*Alosa fallax*) spawning activity. This sampling technique was trialled in 2017 on the River Barrow and River Nore, both of which are designated SACs for twaite shad. Genetic analysis of the eggs collected in these surveys verified that they were twaite shad eggs and St. Mullins, on the River Barrow, and a site downstream of Inistioge, on the River Nore, were confirmed as spawning grounds for this species. Adult runs are also known to occur on two other SAC rivers, the River Suir and Munster Blackwater. The main objective for the current reporting period was to investigate spawning activity on these two channels by targeting potential sites at the top of the tidal range.

Rising water temperature is an important environmental cue for spawning behaviour for many species and shad eggs develop successfully in the range of 15°C to 25°C. Twaite shad spawn from mid-May to mid-July and, in Ireland, they appear to show a preference for the upper tidal reaches of estuaries. Spawning occurs at night over gravel beds in flowing, well-oxygenated, water with a depth of 1 – 2m. The eggs are clear, non-adhesive, semi-buoyant and range in diameter from 1.5 – 5mm (usually 2.4mm). They are broadcast into the water column where the majority sink to the river bed and remain in crevices until they hatch 4 – 8 days later. Samples were collected by kick-sampling for 15 seconds upstream of a hand-held macroinvertebrate net (250µm mesh), working across the channel in a transect. At each site, samples were taken working upstream to avoid re-recording eggs dislodged from an earlier kick sample. Gravels and plant material from the net was sorted by hand and any eggs were placed in bottles containing 70% ethanol for genetic testing.

While the focus in 2018 was to investigate spawning in the Rivers Suir and Munster Blackwater, the River Barrow was also targeted. Sampling of the River Barrow (Figure 3.1) was carried out on the low ebb tide, downstream of the weir in St. Mullins, on 30th May when the water temperature was 20.9°C. The substrate consisted of a mixture of cobbles, gravels and coarse sand. Filamentous algal mats were a feature of the area at the time although the immediate study area was relatively clean. A total of 10 eggs were collected from 4 kick samples in all.

The Munster Blackwater was sampled on 31st May, at a site located downstream of Lismore,

Co. Waterford (Figure 3.1). The water temperature at the time of sampling was 17°C. Seven kick samples were taken and 8 eggs were retained for genetic analysis. Due to the turbid conditions at the site it was not possible to assess the river bed for substrate type. The net samples retrieved gravels, mud and quantities of organic matter.

Two sites were sampled at the top of the tidal influence on the River Suir on 1st June 2018. The first site was located approximately 1km upstream of the 'old bridge' in Carrick-on-Suir and the second site was situated immediately upstream of this bridge (Figure 3.1). Both locations were characterised by a river bed dominated by gravels and cobbles. Due to time constraints and a rising tide, it was only possible to do 11 kick samples in total. A single egg was recorded from 7 kick samples taken at the site located directly upstream of Carrick-on-Suir.

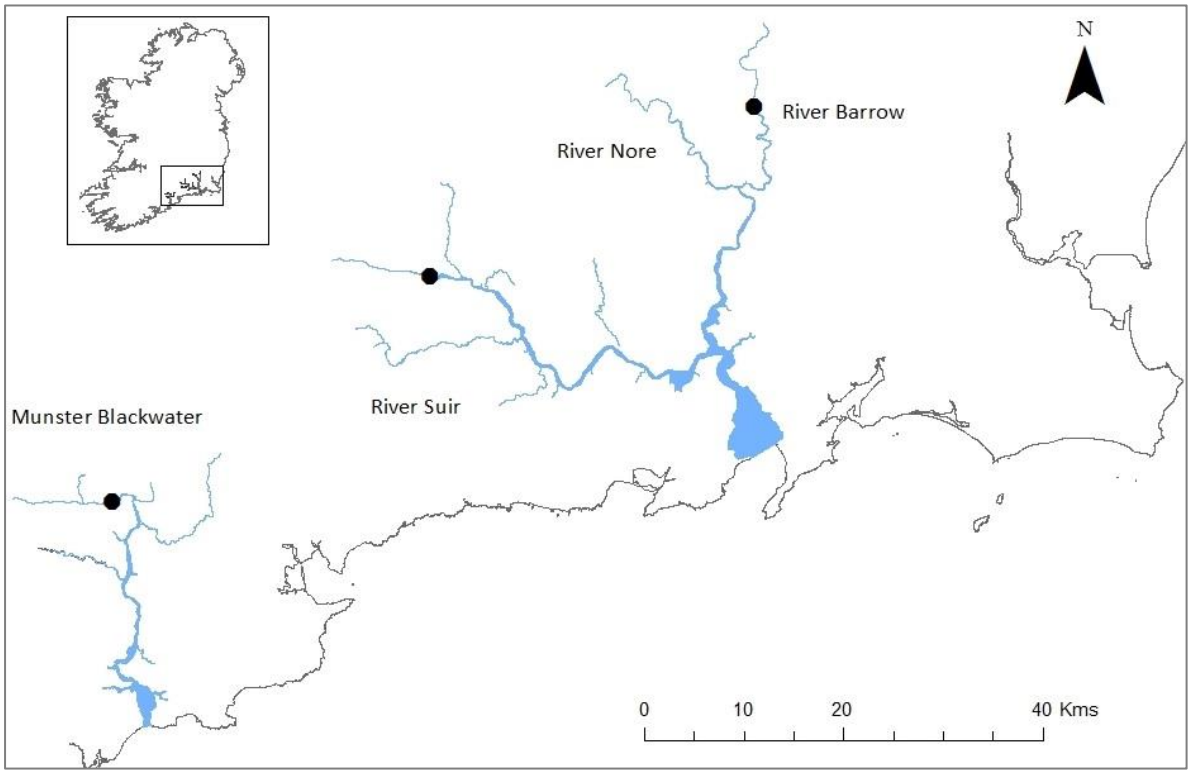

Figure 3.1. Locations of shad egg kick sampling surveys/spawning locations in SACs for twaite shad in 2018.

Abiotic factors such as water temperature and water discharge are important factors in determining the success of a spawning event. Based on data from one river system (River Barrow), water temperatures and flow regime conditions appear to have been favourable during the twaite shad spawning period in 2018 (Figure 3.2). This contrasts with the scenario in 2017, when a flood event during the time of spawning is likely to have flushed any eggs and/or larvae downstream and significantly impacted on spawning success that year (Gallagher *et al*., 2018). The summer of 2018 was notable for being very warm and dry and

drought conditions prevailed across much of the country. Water temperatures reached a maximum of 22.4°C at St. Mullins on the River Barrow during May and June (Figure 3.2), while in the previous 8 years temperatures were at, or below, 20°C during the same period of time.

Pending genetic verification of retained eggs, the surveys carried out in 2018 have confirmed the occurrence of twaite shad spawning and the general location of the spawning grounds on the River Suir and Munster Blackwater. Results have also confirmed that spawning events occurred on these 2 rivers and on the River Barrow in 2018. Kick sampling for shad eggs in the 4 designated SACs represents a candidate sampling strategy for Habitats Directive monitoring requirements for this species in the next 6-year reporting cycle.

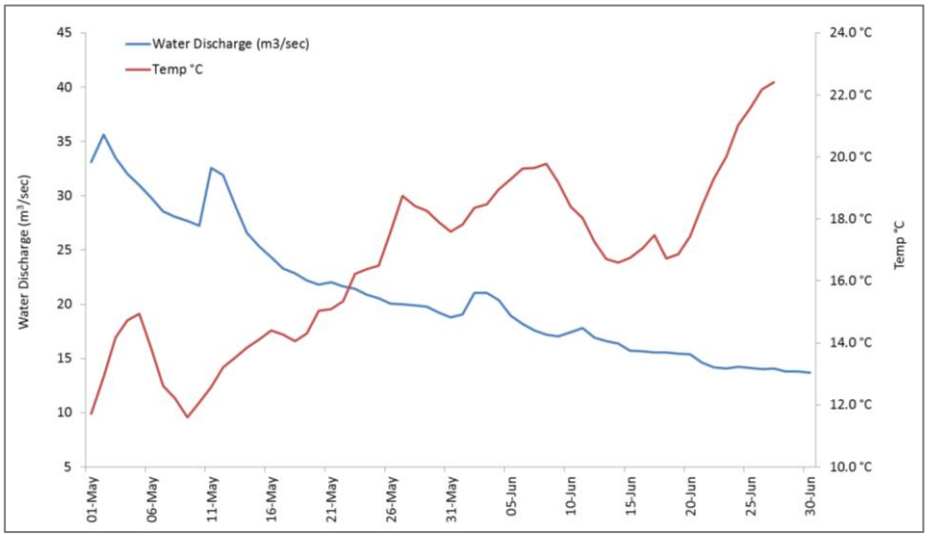

Figure 3.2. Mean daily water temperature (St. Mullins) and water discharge data (Graiguenamanagh gauging station) for the River Barrow during the twaite shad spawning period in May/June 2018.

Plate 3.1. Kick sampling for shad eggs at St. Mullins on the River Barrow in 2018.

3.1.2 Beach seine netting surveys August 2018.

As part of IFI's National Bass Conservation programme, seine netting surveys for juvenile bass (*Dicentrarchus labrax*) were carried out at 5 locations on the Munster Blackwater, Barrow and Slaney estuaries (Figure 3.3 & Table 3.1), all of which are designated SACs for twaite shad. As young-of-year shad are often captured as bycatch in these surveys, they give an indication of successful spawning events for this species in a given year.

Table 3.1. Seine netting locations as part of the Bass Conservation Programme in August 2018.

Estuary	Date	Location	No. Hauls	Mean Salinity (ppt)	Mean Temp. (°C)	No. Shad
Munster Blackwater	07.08.2018	Coolbagh	2	16.7	18.2	3
Munster Blackwater	07.08.2018	Woodpoint	1	22.3	18.1	0
Barrow	08.08.2018	Fisherstown	7	12.5	20.0	32
Slaney	09.08.18	Mary's Point	10	20.0	20.0	0
Slaney	10.08.18	Cat Strand	10	27.0	20.0	0

The surveys were conducted between the 7th and 10th August, 2018. Two types of seine net were used, namely, a Seine 03 and a Collins net. The Seine 03 net measures 30m x 3m, with a 10mm mesh size. The Collins net is 30m x 2m with a 14mm mesh size and a 5m central panel with a 6.5mm mesh. Seine nets are deployed by boat in an arc shape and slowly drawn to shore.

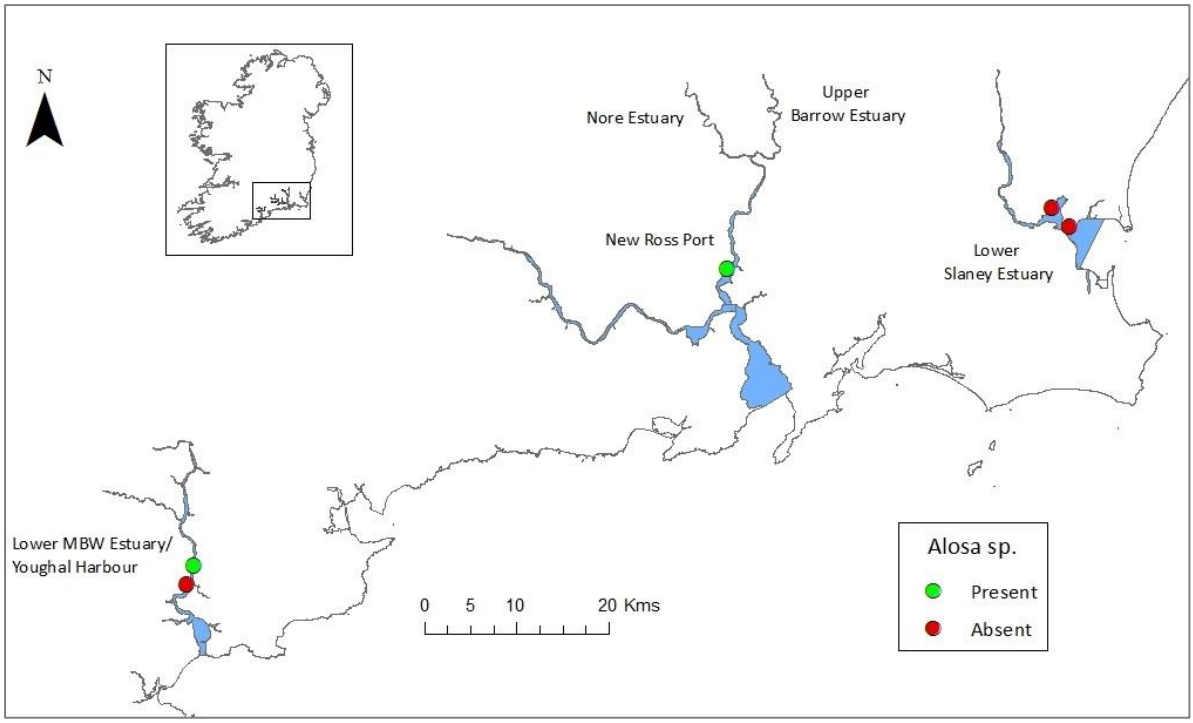

Figure 3.3. Locations of beach seining surveys of estuaries in 2018 as part of IFI's National Bass Conservation Programme, with presence/absence of juvenile *Alosa* sp.

3.1.3 Beach seine netting survey of the Lower Munster Blackwater Estuary/Youghal Harbour

Beach seine netting on the Lower Munster Blackwater estuary/Youghal Harbour occurred at 2 locations (Coolbagh Stream and Woodpoint) on 7th August 2018 (Figure 3.3). Two seine net hauls were taken from the muddy littoral zone at Coolbagh. The site at Woodpoint consists of a small tidal channel which discharges into the main estuary. Sampling was carried out by placing a stopnet across the mouth of the channel at high tide and collecting fish on the ebb tidal flow. Salinity ranged from 16ppt (Coolbagh) to 22ppt (Woodpoint) and the water temperature was 18°C at both locations. Six species of fish were recorded from the combined locations. Three shad, measuring 76, 80 and 81mm (total length), were captured at the Coolbagh site (Figure 3.4). This is the first time shad have been captured in the Bass programme's annual netting surveys of the Munster Blackwater estuary. Previous to this, shad were recorded from trawling surveys of the estuary/Youghal Harbour (Gallagher *et al*., 2017, 2018) No shad were captured at the Woodpoint site.

3.1.4 Beach seine netting survey of the Barrow/Nore estuary (New Ross Port Water Body)

Beach seining on the Barrow/Nore estuary was carried out at a single location (Fisherstown) on 8th August 2018. This site is sampled on an annual basis by the Bass programme. A total of 7 net hauls were taken at this location, and 9 species of fish were recorded. Mean salinity was 12.5ppt and the mean water temperature was 20°C. A total of 32 *Alosa* sp. were

captured and these ranged in length from 61mm to 92mm, with a mean length of 71mm (Figure 3.4). The shad captured at this location could have originated from spawning grounds at the upper tidal limits of the River Barrow (St. Mullins) and/or River Nore (downstream of Inistioge). In previous years, *Alosa* sp. were captured in 2014 (n=7) and 2016 (n=69) at this site.

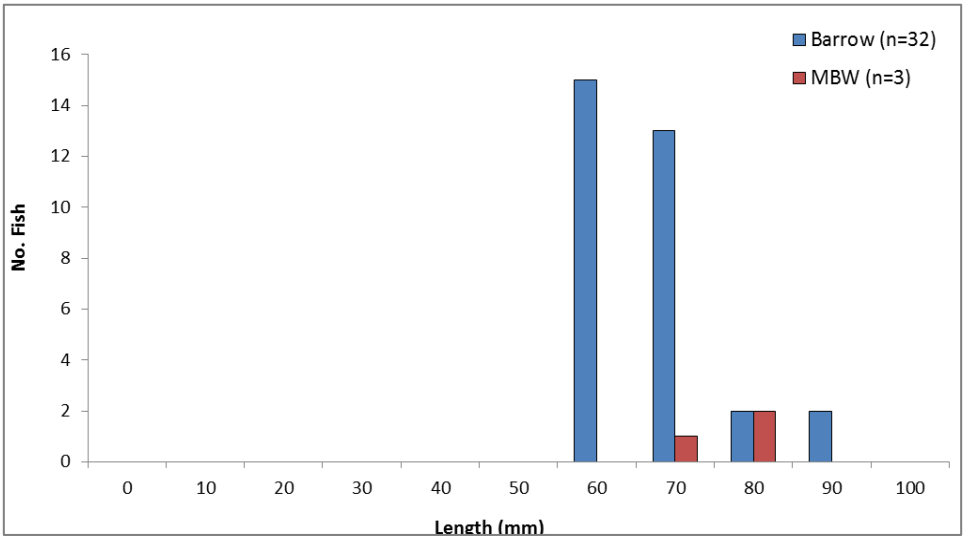

Figure 3.4. Length frequency of juvenile *Alosa* sp. from the River Barrow and Munster Blackwater in the IFI Bass survey programme, August 2018.

3.1.5 Beach seine netting survey of the Lower Slaney Estuary

Two locations (Mary's Point and Cat Strand) in the Lower Slaney estuary were surveyed for their fish communities on the 9th and 10th August 2018 (Figure 3.3). Mean salinity ranged from 20ppt (Mary's Point) to 27ppt at Cat Strand. An average water temperature of 20°C was recorded at both sites. Ten seine net hauls were taken at each site and seventeen fish species were recorded in all. As in previous years, no shad were captured in the Lower Slaney estuary in 2018.

Plate 3.2. Seine netting on the Barrow estuary (Fisherstown) in August 2018.

Plate 3.3. Juvenile shad from seine netting survey of the Barrow estuary (Fisherstown) in August 2018.

3.2 Trawling Surveys

The fish communities in a small number of Irish estuaries were surveyed *via* trawled transects during 2018. These surveys are conducted annually primarily to provide data for IFI's National Bass Programme. Species of interest to the Habitats Directive Monitoring Programme, namely twaite shad, smelt and lampreys, are also occasionally encountered. Repeat surveys for 2018 were undertaken on the Munster Blackwater Estuary and the Barrow-Suir Estuaries during early September. Towed transect trawling was undertaken by a commercial trawler and crew (Plate 3.4) with 2 IFI staff also on board to process catches.

3.2.1 Munster Blackwater Trawling Survey

Trawling surveys on the Munster Blackwater Estuary took place over two days (September 3rd & 4th 2018). A total of four individual trawls were undertaken, each lasting 11 to 12 minutes in total on rising tides, at locations in the lower estuary between Ballinaclash and Ballynatray (Figure 3.5). Average water temperature was 16.8°C (range 16.3-17.2°C). The depth of water along transects varied from 2.5m to 4m. In total, four twaite shad (84mm to 116mm) were captured from 3 transects, 2 at Ballinaclash and 1 at Ballynatray.

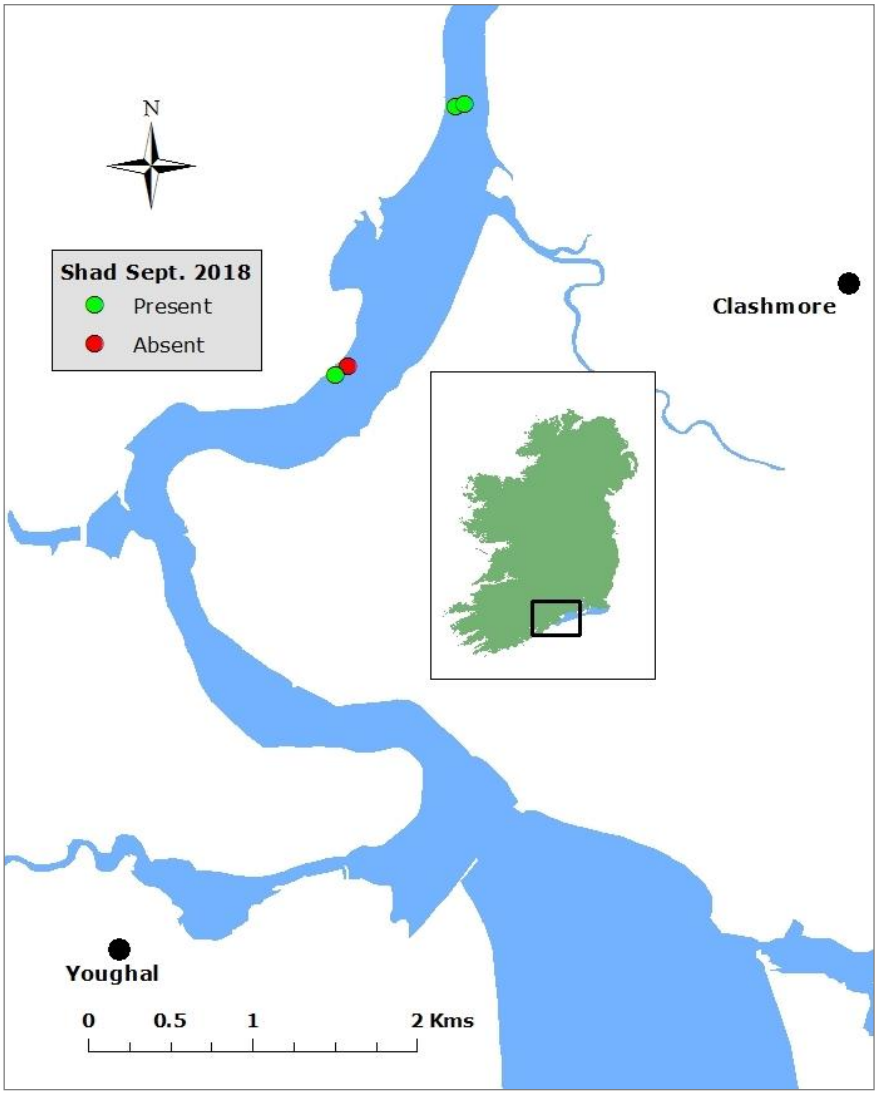

Figure 3.5. Incidence of capture of shad on trawling survey transects (n=4) on the lower Munster Blackwater Estuary in September 2018.

3.2.2 Barrow-Suir Estuary Trawling Survey

Trawling surveys on the Barrow-Suir Estuary / Waterford Harbour took place over two days (September 5th – 6th). A total of six individual trawls were undertaken (Figure 3.6), ranging in duration from 4 to 15 minutes length (average 11 minutes) at locations in the lower Barrow and Suir, namely Fisherstown, Great Island, Kings's Channel, Cheekpoint and Passage East. Water temperatures encountered ranged from 17.0 to 19.8°C, with higher

temperatures recorded in the vicinity of the cooling water outflow from the power generating stations at Great Island. Depth of the water column sampled varied from 2m to 12m, with trawling undertaken across mainly high or flooding tides. A total of 70 twaite shad (81mm-111mm) were encountered at King's Channel (n=63), Passage East (n=1) and Fisherstown (n=6).

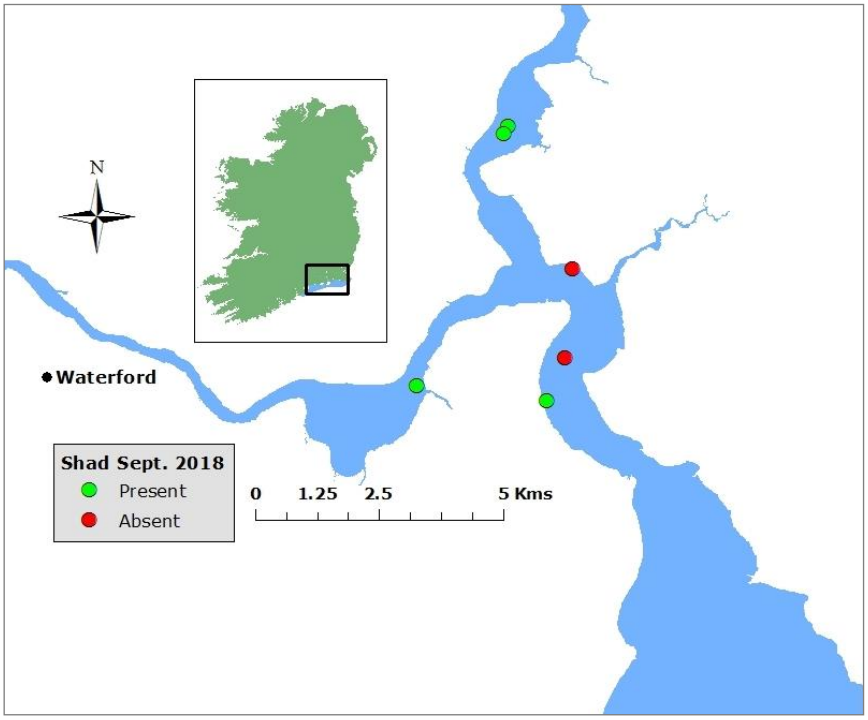

Figure 3.6. Incidence of capture of shad on trawling survey transects (n=6) in the Barrow-Suir Estuary / Waterford Harbour in September 2018.

Plate 3.4. Trawling a transect on the River Barrow at Fisherstown.

3.3 Anadromous Shad Investigations

The acoustic telemetry study on the Barrow-Nore-Suir, initiated in 2012, was continued during 2018. A total of 16 acoustic receivers were deployed throughout the study area during 2018 (Figure 3.7), including 5 on the Suir (Carrick-on-Suir, Fiddown, Grannagh, Waterford City Quays & Waterford Port), 2 on the Nore (Inistioge & Rathsnagadan), 3 on the Barrow between New Ross and St. Mullins, 3 downriver from New Ross at Fisherstown & Barrow Bridge/Kilmokea) and 3 in the outer Waterford Harbour at Passage East, Duncannon and Creadan Head. This network was supplemented by 6 acoustic receivers deployed throughout the lower Suir and Barrow estuaries during June 2018 by IFI Research colleagues as part of a tracking study for the National Eel Monitoring Programme, as well as 4 deployed by the Marine Institute for bass tracking in the upper Barrow estuary either side of New Ross. Locations of receivers were co-ordinated across the 3 research programmes to maximise coverage and reduce inadvertent range overlap. The Marine Institute (MI) also had receivers deployed in Wexford Harbour (n=4), Bannow Bay (n=2) and Youghal Harbour-Munster Blackwater Estuary (n=2). General locations of all receivers, both IFI and MI, are indicated in Figure 3.7.

Plate 3.5. Attaching an acoustic receiver and tether to a Port of New Ross navigation marker buoy in the River Barrow at Fisherstown.

A total of 17 twaite shad were tagged during May 2017 with extended battery life (440 days) transmitters, 10 on the Suir (3 males, 7 females) and 7 on the Barrow (6 females, 1 unknown). The longer life transmitters allowed the potential to detect and track returning fish in 2018. Unfortunately, no returning spawners were detected across the receiver array during 2018.

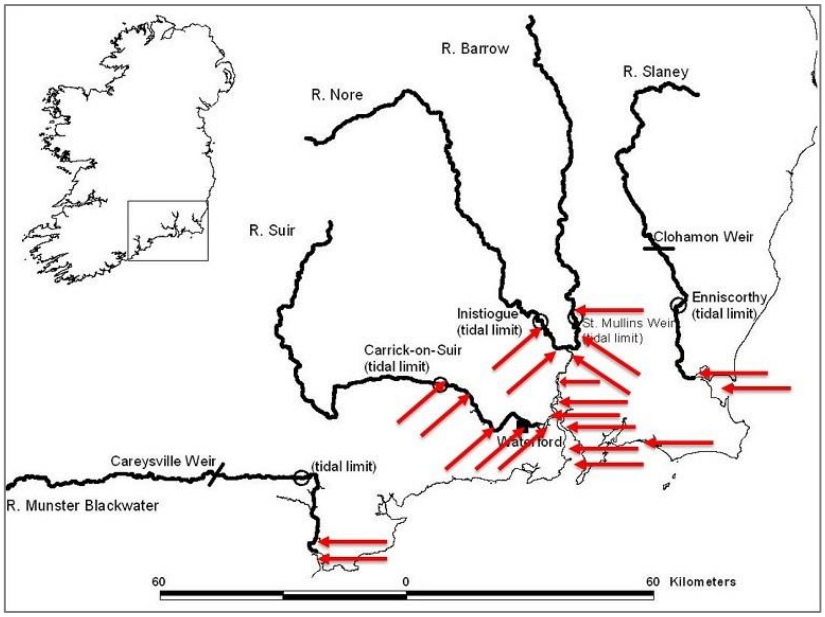

Figure 3.7. Locations of acoustic receivers deployed during 2018 to monitor fish movements in the SE of Ireland. Marine Institute receivers are deployed in Wexford Harbour, Youghal Harbour and Bannow Bay.

Plate 3.6. Attaching an acoustic receiver and tether to a Port of Waterford navigation marker buoy off Creadan Head.

The annual St. Mullins twaite shad angling competition, typically held during May, did not go ahead during 2018 for logistical reasons. Anglers targeted twaite shad as per usual during their spawning migration at St. Mullins, but also at Carrick-on-Suir and at the Hut Pool on the Munster Blackwater.

A total of 13 twaite shad claims (fish >1100g) were forwarded to Irish Specimen Fish Committee (ISFC) for 2018, all taken in the River Barrow at St. Mullins in May and ranging in size from 1540g (520mm) to 1200g (465mm).

Plate 3.7. An angler-caught twaite shad from the Hut Pool section of the Munster Blackwater.

3.4 Use of eDNA to investigate presence/absence of shad species

Shad, primarily a marine species, return to freshwater to spawn between mid-April and early-June annually. Given the possible low numbers of fish that may be present, it was decided to use eDNA to sample for shad. As a pilot study, four tidal areas were selected (Figure 3.8). These estuaries display similar habitats to known areas where shad spawn. The Boyne, Liffey, Lee and Ilen were selected for sampling during 2018. Historically there have been reports of shad on all four of these estuaries. Shad have been taken in the lower estuarine reaches of the Boyne in three successive years around 2010 during trial netting to capture adult salmon for telemetry studies. Anecdotal reports from independent sources record anglers fishing in Dublin city for shads in the 1960s. Records from the Ilen date for the 1959 – 60 period. A single report of shad from Cork Harbour exists from the 1960s and evidence of shad presence (scales from fish but no body) date from *circa* 2015.

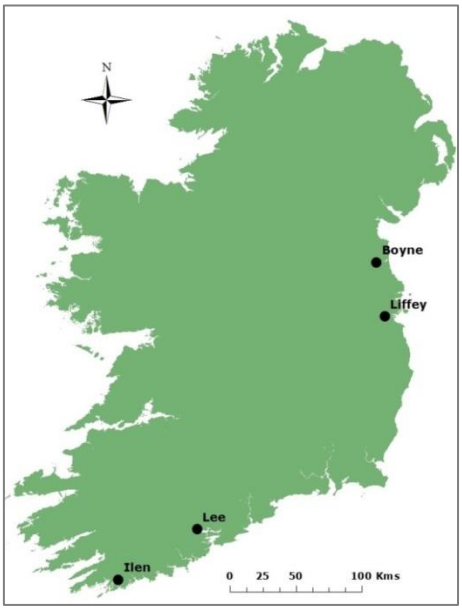

Figure 3.8. Location of eDNA samples collected May-June, 2018.

Each of the four estuaries was sampled twice between 23rd May 2018 and 14th June 2018 (Table 3.2). It is during this period that the maximum number of shad and sea lamprey would be traversing the water column upstream to spawn. A bottle of deionised water was brought to the sampling location and treated as a control when the local samples were taken. Samples were collected as the high tide was starting to ebb. This was to maximise the amount of potential eDNA which was likely to be dispersed in the water column. On each sampling occasion and at each sampling site, three replicate samples were collected. The samples were placed in a cool box with frozen ice packs and placed in a freezer as soon as possible. NUI (Dublin) will undertake the analysis of the samples in order to identify the eDNA present in the samples. The samples can be analysed for both sea lamprey and shad eDNA at the same time, thus feeding into a knowledge gap in the Habitats Directive Article 17 reporting.

Table 3.2. Rivers, dates and location of eDNA samples collected.

River	Date	Location
Liffey	28.05.18 & 14.06.18	Islandbridge
Ilen	24.05.18 & 06.06.2018	at jetty d/s Skibbereen
Lee	23.05.18 & 05.06.2018	Lee Rowing Club
Boyne	29.05.2018 & 13.06.2018	Slip d/s motorway bridge

3.5 Conclusion

The seine netting and trawling surveys provide valuable information on whether there have been successful spawning events for shad in the SACs in the southeast of Ireland. Surveys have been carried out in the Barrow-Suir estuary/Waterford Harbour on an annual basis since 2014. Young-of-year shad were captured in seine nets from the site at Fisherstown in 2014, 2016 and in the current year, with numbers ranging from n=7 (2014) to n=69 (2016). The Fisherstown site appears to be a reliable location for the capture of juvenile shad and results indicate successful spawning in these years (the site was not sampled in 2015). No shad were captured at Fisherstown in 2017. As discussed, it is likely that a major flood event in early June 2017 had a negative impact on shad recruitment that year (Gallagher *et al*., 2018). Apart from 2016, shad were recorded in all years in the trawling surveys. Trawling surveys have been successful in capturing 1+ shad but 0+ shad were also caught in 2014 and in the current year.

Trawling surveys in the Munster Blackwater have been carried out annually since 2016. Small numbers of shad were caught in all years with, notably, young-of-year fish captured in

the current year indicating a spawning event had occurred in this system. The presence of 0+ fish from seine net hauls at the Coolbagh site this year provided further confirmation that a spawning event occurred in the Munster Blackwater in 2018.

Several trawling and netting surveys have been carried out in Wexford Harbour since 2015 but no shad have been captured to date.

4. Pollan Programme

Spawning Habitat Surveys 2018

Pollan are protected as an Annex V species under the Habitats Directive (92/43/EEC), with populations extant in Loughs Allen, Ree and Derg (Figure 4.1). Pollan are also present in two lakes in Northern Ireland, Lough Neagh and Lower Lough Erne.

In July 2018, low water levels on Lough Allen following flood mitigation measures and a protracted dry spell provided an opportunity for surveying and evaluation of potential pollan spawning locations. Over 2 days (July 16th – 17th) all exposed headlands, shorelines, islands and submerged gravel shoals were investigated along the northern, western and lower eastern shores of the lake. This spawning location survey was a resumption of a survey commenced in a previous year (August 2013) and curtailed due to unfavourable weather conditions. The present fieldwork served to review previously identified locations and to extend the survey to provide complete coverage of the lake.

Figure 4.1. Map outlining locations of pollan lakes in Ireland.

Potential pollan spawning habitat was noted at numerous locations around the entire circumference of the lake, as well as on the flanks of several of the islands. The eastern and northern shores are particularly exposed, especially so at the outflow of the Yellow River (NE shore) and the islands off Corry Point (N. shore). Drumman's Island and Corderry shore in

the NW corner of the lake comprise sections of finer pebbles and gravels.

Plate 4.1. Low-lying island and rocky surrounds off Corry Point.

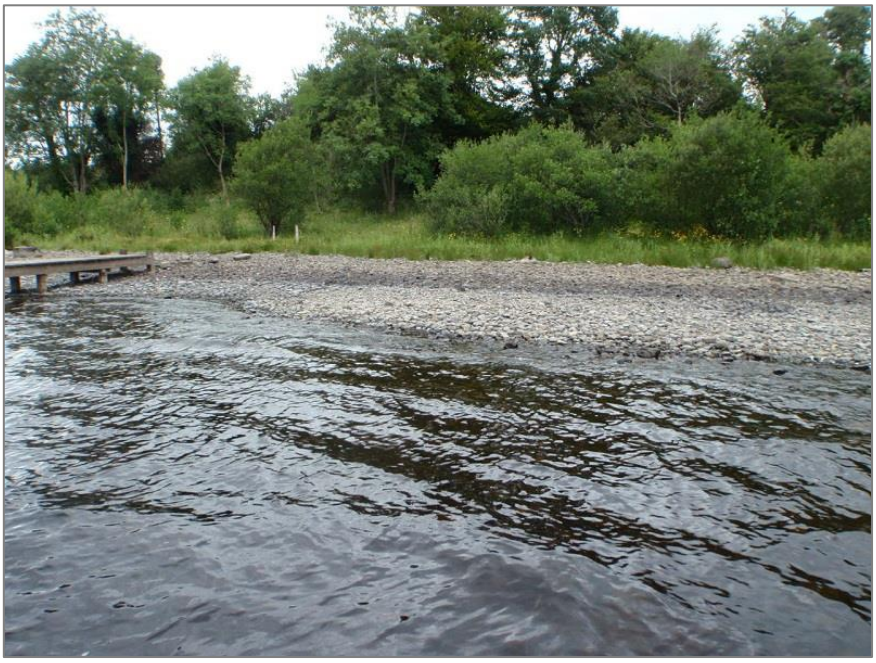

Plate 4.2. Northern shoreline at Corderry.

The western shore from Spencer Harbour southwards past Cartrun Beg headland and the Cross Islands is typically more sheltered, with long uninterrupted sections of shore consisting of smaller cobbles, pebbles and gravels. O'Reilly Island (Inisfale) at the southern tip of the lake is a long thin promontory extending into the lake, again characterised by a long shoreline of smaller substrates.

Plate 4.3. O'Reilly Island (Inisfale) shoreline towards the south of the lake.

The eastern shore comprises several exposed headlands (O'Dwyer's Point, Cormongan, Cleighran, Fahy Point) as well as islands (Long Island, Cormongan Island) where pollan could be expected to congregate.

Plate 4.4. Cormongan Island off the eastern shore.

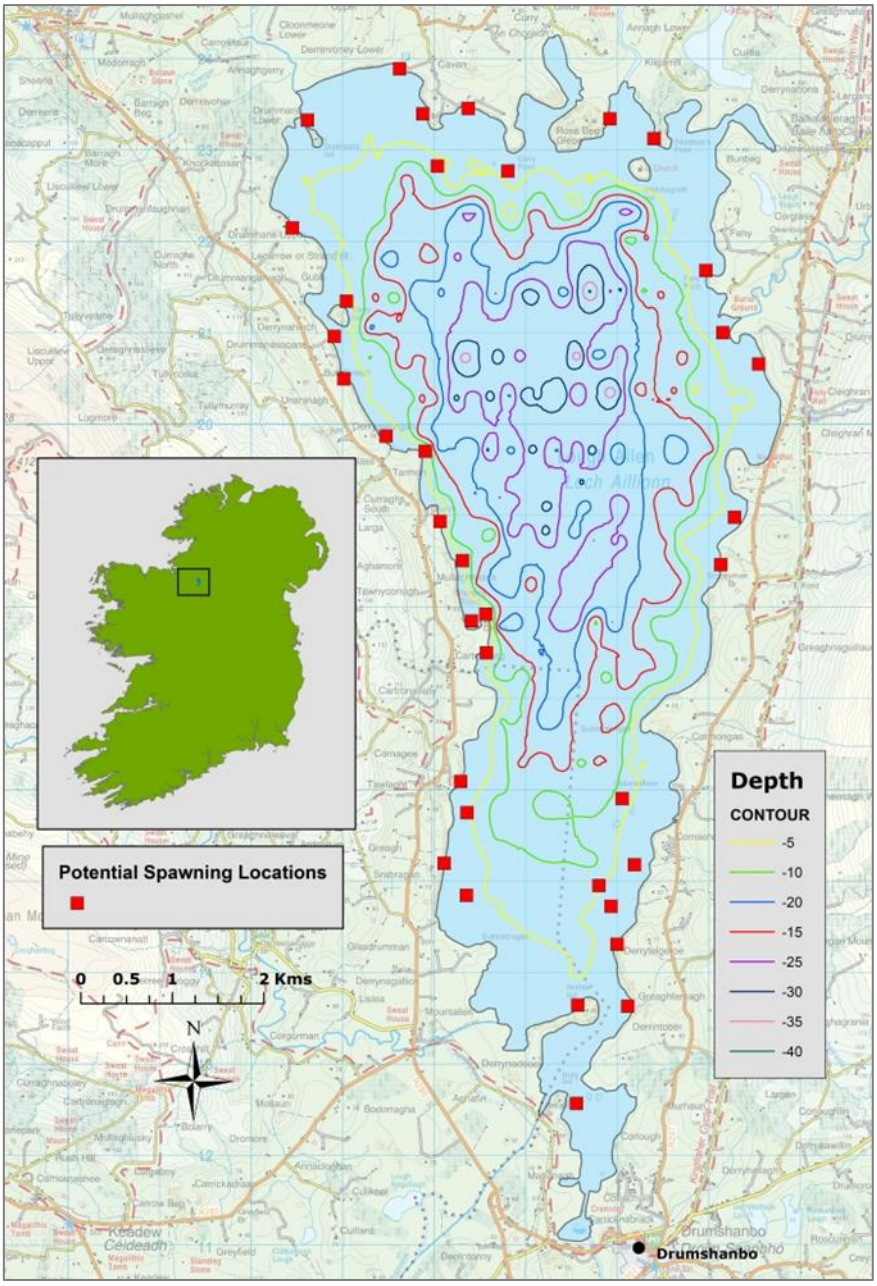

Figure 4.2. Locations of potential pollan spawning habitat along Lough Allen shores.

Speculation aside (Dabrowski,1981; Rosell *et al.*, 2004), the habitat preferences of spawning pollan in Irish lakes is unknown. Anecdotal evidence exists for Lower Lough Erne (Rosell, 1997), with fishermen recounting pollan spawning over hard substrates. A study of spawning habitats used by Scottish powan (*Coregonus lavaretus*), a similar coregonid species to pollan, suggested that substrate comprising smaller cobbles, pebbles and fine gravel afforded best protection for eggs from predators (Etheridge *et al*., 2011). Fine sand or larger cobbles/boulders both lacked the depth and complexity of interstitial spaces available in smaller cobble/pebble/gravel substrate, providing refuge for developing ova from predatory cyprinids and percids. Locations where these conditions currently exist around the shores of Lough Allen are shown in Figure 4.2.

This survey and its identification of potential spawning locations is pertinent with regard to on-going reviews dealing with flood regulation on the River Shannon as a whole, involving central government, ESB, Waterways Ireland and other relevant bodies. One line of thought involves lowering the surface level of Lough Allen in summer months in order to create additional storage capacity for water in the autumn-winter period. Adjusting water levels would have impact on leisure craft entering and navigating in the lake. Likewise, adjustment of water levels could impact on the areas of spawning habitat available to pollan.
The ESB's fisheries team undertook an extensive netting survey for spawning pollan in the winter period 2018-19, targeting selected areas based on the IFI survey described here. The pollan survey did not yield any spawning fish. Discussion between ESB fisheries and IFI have identified the need for a very detailed bathymetric map of Lough Allen with water surface levels fixed to Ordnance Datum so that accurate predictive modeling can be undertaken to examine impact of adjusting water surface level on the availability of potential pollan spawning habitats.

The pollan spawning habitat surveys of L. Allen and L. Ree, now fully complete, provide baseline substrate suitability assessment and identifies sections of shoreline with potentially high ecological significance for this threatened coregonid species. Many of these areas will also be highly vulnerable, given plans for maintenance of lower winter water levels in the future. There is an overarching requirement to definitively identify actual pollan spawning habitats in Irish lakes, as well as investigating other aspects of their behaviour and ecology. A carefully planned telemetry study in one of the 3 major Shannon lakes could address this dearth of knowledge.

5. Smelt Programme

5.1 Juvenile Smelt Programme

5.1.1 Beach seine netting surveys August 2018

Beach seining surveys of the Barrow, Slaney, Munster Blackwater, Lee, Maigue, Shannon and Rogerstown estuary were carried out by the Bass Conservation Programme in August 2018. While European bass (*Dicentrarchus labrax*) was the target species, juvenile smelt (*Osmerus eperlanus*) were recorded from the Barrow, Maigue and Shannon estuaries. Two types of seine net were used, namely, a Seine 03 and a Collins net. The Seine 03 net measures 30m x 3m, with a 10mm mesh size. The Collins net is 30m x 2m with a 14mm mesh size and a 5m central panel with a 6.5mm mesh. Seine nets are deployed by boat in an arc shape and slowly drawn to shore. All species of fish that were captured were counted and measured on site.

Seven seine net samples were taken from a single location (Fisherstown) in the Barrow (New Ross Port water body) on 8th August 2018 (Figure 5.1). Mean salinity was 12.5ppt on the day, with a mean water temperature of 20°C. A total of 376 juvenile smelt were recorded from the 7 net hauls. Of those that were measured (n=284), they ranged in length (total) from 54mm - 86mm, with an average length of 69mm (Figure 5.2). This site is surveyed annually by the Bass Programme and, in previous years, 181 (2012) and 114 (2016) juvenile smelt were recorded.

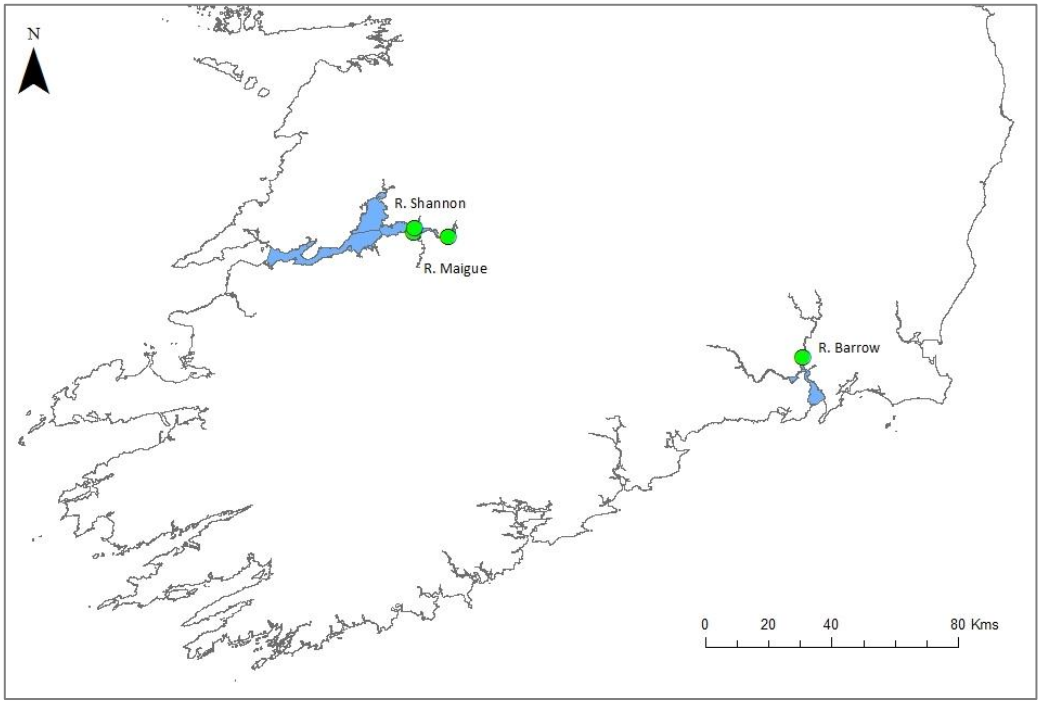

Figure 5.1. Locations where juvenile smelt were captured from seine netting surveys carried out by IFI's National Bass Conservation Programme in 2018.

Two locations on the Maigue estuary were surveyed on 22nd August 2018. Four hauls were taken in total, with salinity ranging from 15ppt – 21ppt and water temperatures ranging from 19°C - 21°C. A total of 19 smelt were captured from the Maigue estuary, measuring 42mm – 68mm and with a mean (total) length of 50mm (Figure 5.2).

Fifteen smelt were recorded from 4 seine net samples taken from the Shannon estuary (Upper Shannon Estuary and Limerick Dock Water Body). Sampling was carried out on 23rd August with water temperatures ranging from 18°C - 19°C. Salinity measurements indicated freshwater conditions (0.2ppt) at the most upstream location (Limerick City) and brackish water conditions (12ppt) at the most downstream site located near the confluence with the River Maigue. The smelt ranged in length from 37mm – 65mm and had a mean length of 49mm (Figure 5.2). Smelt have been recorded previously in seine netting surveys of the Shannon, Maigue and Fergus estuaries in 2008, 2014 and 2017 as part of IFI's WFD monitoring of transitional waters (http://wfdfish.ie/).

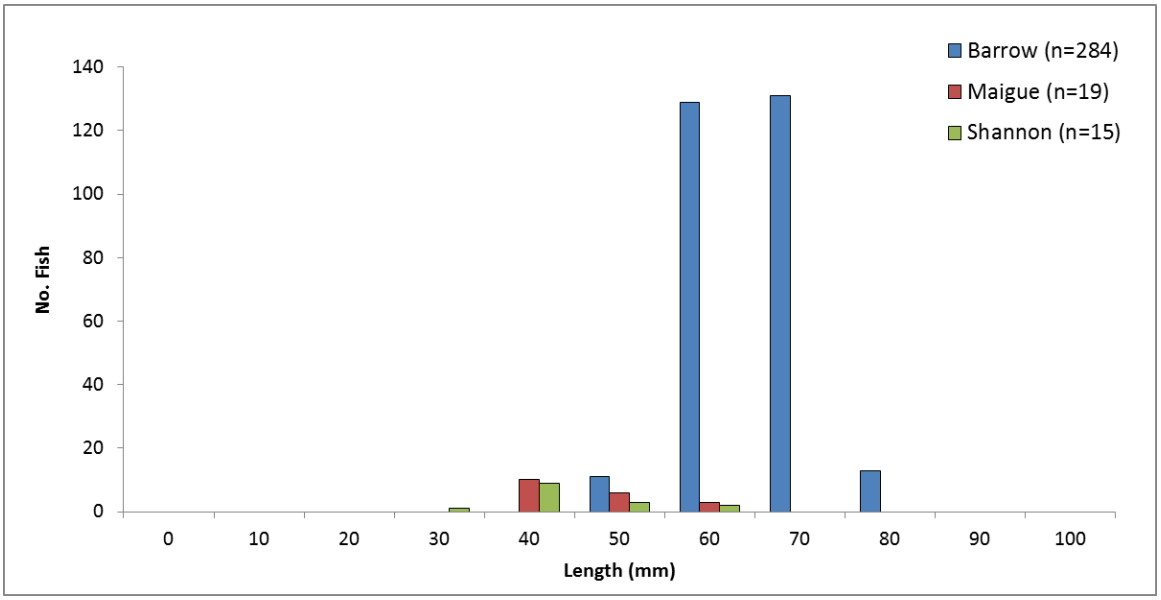

Figure 5.2. Length frequency of juvenile smelt from the Barrow, Maigue and Shannon estuaries in 2018.

5.2 Trawling surveys

Smelt were encountered during some of the trawling surveys documented previously (Section 3.2). On the Munster Blackwater Estuary a single smelt (181mm) was captured during one of the two trawls undertaken at Ballynatray (Figure 5.3).

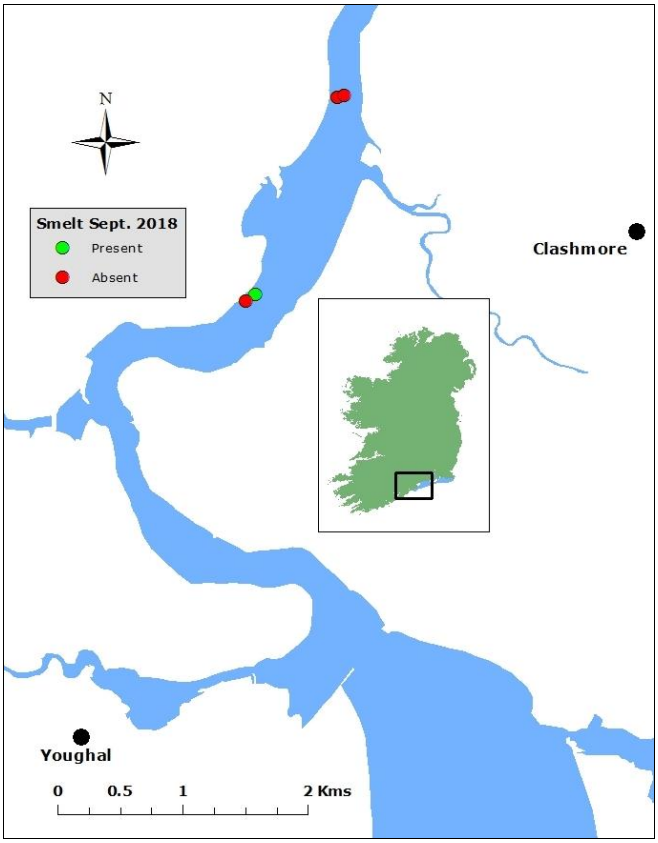

Figure 5.3. Incidence of capture of smelt (n=1) on trawling survey transects (n=4) in the Munster Blackwater Estuary in September 2018.

Seventeen individuals, ranging in length from 95mm to 248mm, were captured on the Barrow-Suir Estuary along transects at Passage East (n=8 smelt), King's Channel (n=6), Fisherstown (n=1), Great Island (n=1) and Cheekpoint (n=1), respectively (Figure 5.4).

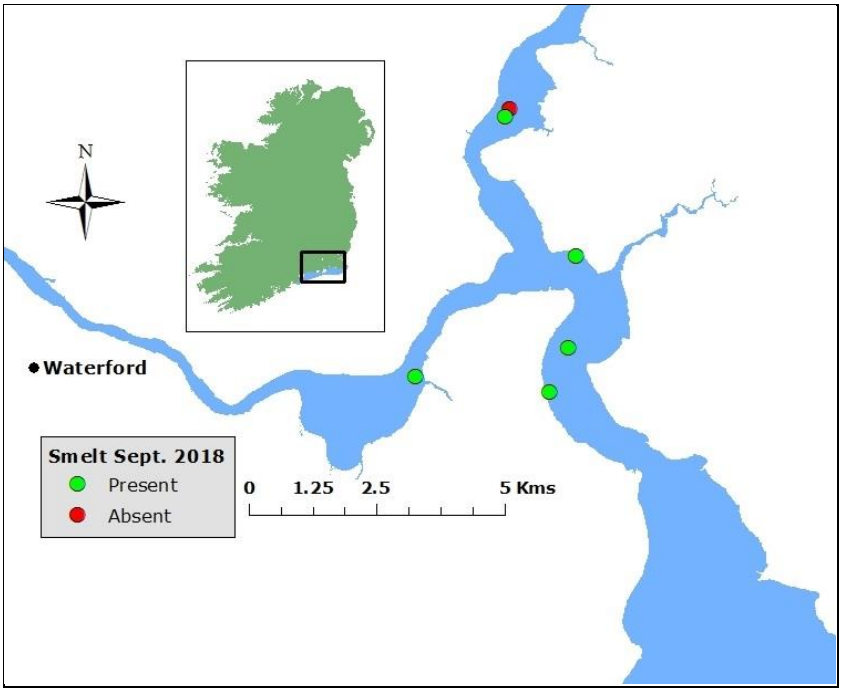

Figure 5.4. Incidence of capture of smelt on trawling survey transects (n=6) along the Barrow-Suir Estuaries in September 2018.

6. River Connectivity – barriers to fish migration in SAC rivers

Within the Habitats Directive team, the focus has been to survey barriers in main stem SAC channels that may impact on Atlantic salmon and sea lamprey migration. The data from sea lamprey spawning and redd surveys indicate strongly that barriers in rivers appear to impede sea lamprey upstream migration. One of the Conservation Objectives for sea lamprey status is that adult sea lamprey should have unimpeded access along 75% of the main stem length of each of the SAC rivers. The Habitats team is using the SNIFFER barrier assessment protocol (SNIFFER, 2010) to examine all barriers in the SAC rivers designated for sea lamprey migration, to be completed by end 2018.

Members of the Habitats team contributed to the production of a peer-review paper published during 2018 (Barry *et al*., 2018) that compared the outcomes of two barrier passability protocols, the SNIFFER III, as used by IFI, and the more-recently developed French ICE method. Both protocols provided a high degree of similarity in outcomes for structures that were 'Impassable' for Atlantic salmon and for sea lamprey. The analysis also indicated that a large number of structures installed as "fish passes" were also rated as failing to pass these two target species in the flow conditions prevailing at the time of survey.

6.1. Overall SNIFFER barrier assessment programme in SAC rivers

A target for the Habitats Directive fish programme was to SNIFFER-survey all identified major barriers in the SAC main stem channels designated for sea lamprey by end 2018. This task would coincide with the end of the current 6-year reporting cycle for Article 17 reporting under Habitats Directive and it was considered that the information compiled would be relevant in identifying some of the Threats or Pressures faced by the migratory fish species in Irish waters listed in the Habitats Directive.

A desk study of aerial imagery and of contemporary and historical digital maps has indicated that some of the SAC channels have a high level of identified historical barriers, many with an 'unclear' status as to their current physical condition and their capacity to 'pass' migrating adult salmon and sea lamprey. A review of 'surveyed' versus 'potential barriers' on the main stem SAC rivers identified a substantial number of historical weirs that would require to be assessed on-site to examine their condition and the requirement or otherwise for a SNIFFER survey. On this basis the team examined structures on the Slaney, Nore, Suir and Munster Blackwater during 2018 and surveyed locations of bridge aprons, weirs in various states of repair and any other man-made structures observed from aerial imagery or from local knowledge. Structures on the Nore included the rock ramp structure at Lacken weir, a

flood/velocity regulating weir (the Bishop's weir) constructed during the Kilkenny city flood relief scheme in the early 2000s, and an older upstream mill on the Bleach road. All of these were SNIFFER-surveyed in 2018. The survey programme on the River Suir continued upstream from Cahir town and included SNIFFER surveys on the "bakery weir" upstream of Cahir, a small hydro-scheme weir, hydrometric gauging station and historical structure near Holycross and two full-channel width structures functioning historically as eel-weirs downriver of Golden.

Despite this level of survey, the overall ambition of completing SNIFFER surveys on all of the man-made structures on the SAC rivers by end 2018 was not fully achieved. The stand-out locations requiring to be surveyed include (a) the majority of the navigation weirs on the River Barrow, (b) the regulating weir on the River Corrib in Galway city, (c) the weir and fish counter facility on the River Garavogue in Sligo town and (d) the Ridge Pool area at the downstream end of the freshwater River Moy in Ballina. A small number of structures remain to be inventoried and surveyed on the main stem Slaney, Nore, and Suir, including derelict weirs that are breached. These may be forming velocity barriers in low flow conditions, when all of the channel flow is routed through the breached section.

The River Boyne is designated as a SAC for Atlantic salmon but not for sea lamprey. As such, it has not been considered, to date, for SNIFFER surveying of barriers. The main stem of the river and its major sub-catchment, the Kells Blackwater, have been arterially drained upstream from the town of Navan. In the course of this drainage work a number of large weirs were removed, facilitating passage of fish and creating shallow gravelled areas subsequently utilised by Atlantic salmon for spawning. The section of the main River Boyne downstream of Navan was not drained and aerial imagery indicates that this section contains approximately 24 structures over a distance of *circa* 25 km down to the tidal limit at Oldbridge. The large number of historical structures relates both to use of hydropower as well as to the creation of the Boyne Navigation, when a series of lock gates were installed to create a navigable waterway from Drogheda, at the head of the tide, up to Navan. An assessment of passability at this series of structures would be relevant in regard to:

- Atlantic salmon, and any adverse impacts of the structures on the migration of this species
- Sea lamprey and the non-designation of the Boyne as a SAC for this species, while the Boyne is designated for river lamprey
- Twaite shad, a member of the herring family that can migrate into freshwater to spawn.

Individual twaite shad have been recorded in the lower reaches of the estuary of the Boyne near Mornington-Baltray. The long, linear form of the estuary and the large freshwater catchment discharging into it all identify the Boyne as a candidate twaite shad river but the presence of the large number of barriers would be a significant obstacle to passage for the shad. A survey programme over the 2019 – 2021 period on the series of Boyne barriers would provide a sound information base that would feed into Habitats Directive fish conservation management as well as the National Barriers Programme of IFI.

7. Conclusions and Plans for Future Work

The six-year surveillance and monitoring programme for fish species (under Article 11 of the Habitats Directive) was completed in 2018. All data gathered over this timeframe were used to update the conservation status of each species for Article 17 reporting. The Habitats team completed separate reports for the 3 lamprey species, twaite shad, Killarney shad and pollan and these will form part of a composite National report to be submitted to the EU in 2019 by the National Parks and Wildlife Service (NPWS).

Catchment-wide surveys of larval lampreys are a major component of the annual fieldwork schedule and 2018 saw the completion of a programme of repeat surveys of catchments first surveyed in NPWS studies from 2003 – 2007. This was a substantial undertaking and has provided important baseline information on the status of larval *Lampetra* spp. populations in SAC catchments. These repeat surveys will also enable a comparative assessment of these populations over time.

The focus in 2019 will be to review and revise, where necessary, the monitoring programme for each of the fish species for the next six-year cycle (2019 – 2024), particularly in relation to the larval lamprey surveys, which form the basis of Article 17 reporting on brook lamprey. An emphasis will also be placed on monitoring adult and juvenile river lamprey for which there is currently limited data. River lamprey is a challenging species to monitor due to its elusive nature and the inability to separate *L. fluviatilis* from *L. planeri* at the larval stage. It is possible to distinguish between the two species, however, in the post-metamorphic (macrophthalmia) phase and electro-fishing surveys for this developmental stage will be trialled over the coming years. These surveys will be conducted in SAC catchments in late autumn/winter, while extent of river lamprey spawning will be investigated from redd surveys to be carried out in the springtime.

A number of new sampling techniques and technologies have been adopted over the past number of years. Environmental DNA (eDNA) is a simple and effective tool for investigations on aquatic species and there is great potential, over the next reporting cycle, for assessing the occurrence and spatial extent of both sea lamprey and twaite shad, using this technique. The use of drones was trialled in 2018 to investigate the presence of sea lamprey redds during float-over and hotspot surveys. Annual redd count surveys will continue to be an important element of monitoring sea lamprey spawning activity in the next cycle and it is hoped that the use of drones will give added value to these surveys.

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