Fish Stock Survey of Selected Lakes and River Sites in the Owenriff Catchment

2017

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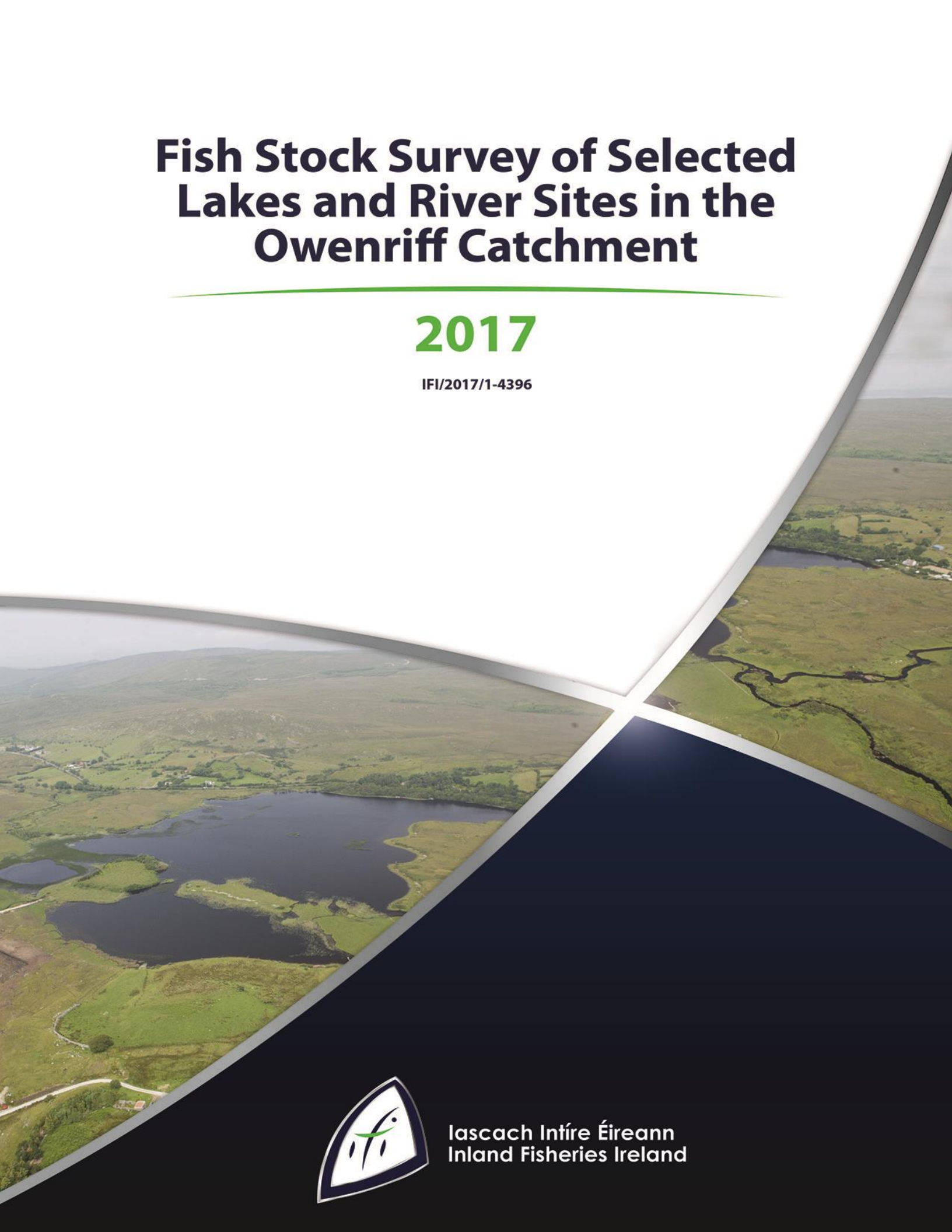

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National Research Survey Programme

Fish Stock Survey of Selected Lakes and River Sites in the Owenriff Catchment, 2017

Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

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Executive Summary

Inland Fisheries Ireland undertook a catchment wide electrofishing survey in the Owenriff River and its sub-catchments in summer 2017. The Owenriff River drains into Lough Corrib Upper downstream of Oughterard, Co. Galway. The Owenriff catchment is located within two different Special Areas of Conservation (SAC) both of which support two Annex II species of the E.U. Habitats Directive (92/43/EEC), namely Atlantic salmon (*Salmo salar*) and freshwater pearl mussel (*Margaratifera margaratifera*) (NPWS, 2005).

A total of 17 river sites were surveyed across the Owenriff catchment to assess the current status of the fish stocks present; five sites on the Owenriff main channel and twelve sites in seven sub-catchments. In addition two lakes, Lough Bofin and Lough Agraffard were also surveyed. All fish species present were counted and identified to species level. Information on abundance, biomass, age, growth and diet are reported for certain species.

Four fish species were recorded during the river surveys and three species in the lake surveys. Brown trout was the most common fish species recorded in river sites, occurring in 82% of sites, followed by salmon in 47% of sites, minnow in 35% sites and pike in 18% of sites. Pike were the most common fish species captured in the survey gill nets in Lough Agraffard while equal numbers of brown trout and pike were captured in Lough Bofin. Pike and eel were also captured in the fyke nets in both lakes.

Brown trout in river sites surveyed ranged in length from 3.5cm to 17.2cm. Only two 2+ and one 3+ brown trout were encountered across the 17 sites. Salmon ranged in length from 3cm to 11.8cm, three age classes were present with 0+ the most abundant cohort. Four pike were recorded during the river survey ranging in length from 10.5cm to 26.5cm and aged 0+ and 1+. Only one age class of brown trout (2+) was recorded in both lakes indicating a possible failure in recruitment in at least the previous two years. In contrast the brown trout captured in another lake within the catchment with no pike present (Lettercraffroe Lough) during 2016 ranged in age from 0+ to 4+ indicating recruitment success in the previous four years.

In general minimum density estimates for brown trout and salmon were relatively poor at many of the river sites surveyed during 2017. Overall 0+ brown trout and salmon were more dominant than 1+ and older fish. In general the proportions of 1+ and older brown trout were lower at many sites across the catchment in 2017 than in 1997. Brown trout abundance was also relatively poor in the two lakes surveyed.

There is evidence to suggest that salmon and brown trout numbers in river sub-catchments across the Owenriff catchment have declined since the previous survey in 1997. Data analysis shows that the density of the majority of comparable sites life stages for both trout and salmon were lower in 2017 than those recorded for 1997 with the exception of 1+ and older brown trout at one site in the Derrylaura sub-catchment. Total brown trout density was significantly lower in 2017 than 1997 at five matched sites. In general salmon were more prevalent across the catchment in 1997. Definitive conclusions were difficult to determine for both lakes surveyed due to the limited number of fish recorded, in particular for Lough Bofin; however brown trout abundances were poor and significantly lower in comparison to other lakes within the Owenriff (Lettercraffroe) and in neighbouring catchments (Loughs Doo, Glencullin, Kylemore and Lettercraffroe) where pike are not present.

Pike were confirmed present for the first time in two lakes in the Owenriff catchment in 2009 by IFI WRBD staff. They weren't recorded during the 1997 and 2007 catchment wide river electrofishing surveys and the surveys of Lettercraffroe Lough in 2010, 2013 and 2016. Pike were recorded in a quantitative river electrofishing survey at the designated WFD fish surveillance monitoring site for the first time in 2015. During the 2017 survey pike were recorded at three river sites including the most upstream sub-catchment and in the two lakes surveyed, indicating a range expansion over the past 20 years. Results from the 2017 survey suggest that pike are present all over the Owenriff catchment, in areas where they can freely gain access and in some areas where they cannot naturally gain access (gradients > 7%). The relative abundance of pike captured in Loughs Agraffard and Bofin was similar when compared to other low alkalinity lakes in Co. Galway, Leitrim and Mayo, containing pike (no significant difference).

Invertebrates dominated prey items in the pike stomachs examined in both lakes, with the three invertebrate prey types (shrimp, damsel fly and midge) combined accounting for in excess of 70% IRI (Index of Relative importance) for pike in both lakes. Young of the year (YOY) pike were found to be the

only fish prey found in the stomachs examined. However, caution must be used when interpreting the data as it provides just an insight into the diet at the time that the survey was conducted and is limited by both the size of the sample and also by the relatively small size range of the fish captured in the nets.

Four river sites were assigned Good fish status; however the remaining 13 sites were assigned moderate or lower fish status (nine Moderate fish status, two sites Poor status and two sites Bad fish status). One site on the main channel (Site 15) is a designated surveillance monitoring site for fish and its ecological fish status has deteriorated from Good in 2010 and 2015 to Moderate in 2017. The two lakes surveyed (Lough Bofin and Agraffard) were assigned a fish ecological status of Poor and Bad respectively. In contrast Lettercraffroe Lough (a lake within the catchment with no pike present) was assigned a status of Good in 2016. . These failures were mainly due to the absence, lower than expected abundance or missing age classes of type specific indicator species (i.e. brown trout and salmon). In contrast the most recent EPA WFD assessment of the catchment (2010 to 2015) has assigned the entire Owenriff main channel and most of its sub-catchments as Good ecological status, apart from the Glengawbeg sub-catchment and Lough Bofin which were assigned High status indicating that there are little or no water quality and other anthropogenic pressures in the catchment.

As there are little or no major anthropogenic pressures in the catchment to cause the decline in fish stocks, it is reasonable to infer that the introduction of pike and their subsequent range expansion in the Owenriff catchment (with impacts of competition for food and space and predation on resident and migratory fish) is the main factor causing the decline of brown trout and salmon in the Owenriff catchment. Research from Europe and North America supports this finding.

1. Introduction

In 2017 Inland Fisheries Ireland (IFI) undertook an electrofishing survey of selected river sites in the Owenriff catchment, Co. Galway (Fig. 1.1). The study area covered the Owenriff main channel and seven sub-catchments. In addition two lakes were also surveyed, Loughs Bofin and Agraffard.

1.1 Previous fish stock surveys

Catchment wide fish stock surveys were conducted at 34 river sites in 2007 (WRBD, 2008) and 28 river sites in 1997 (IFI, unpublished data). Prior to 1997, the Owenriff main channel, along with the Bunowen and Letterfore tributary rivers were surveyed in 1979, 1980 and 1981 (Browne and Gallagher, 1980, 1981 and 1982). Results from these surveys indicated that all three were productive salmon fry rivers; however the numbers of trout recorded were poor. Salmon, brown trout, minnow, three spined stickleback and eel were the only fish species recorded during the 1997 and 2007 surveys. The results of the 2007 fish survey illustrated the presence of salmon throughout the catchment. The survey also illustrated that the zone extending for 1500 meters between the waterfall at Canrawer, Oughterard and the Ordnance grounds is the most important zone for salmon spawning in the catchment (WRBD, 2008). As part of the WFD river monitoring programme one site on the Owenriff main channel has been surveyed in 2010 and again in 2015. Pike were recorded at the site in 2015.

Lettercraffroe Lough (Fig. 1.1) has been surveyed on four occasions between 2007 and 2016 (Kelly *et al*., 2007, 2011, 2014 and 2017). A total of four fish species were recorded in Lettercraffroe Lough in September 2016. Roach was the most common fish species recorded, followed closely by brown trout. Three-spined stickleback and eels were also recorded. During the previous surveys in 2007, 2010 and 2013 the same species composition was recorded with the exception of eels, they were not recorded in 2013 (Kelly *et al*., 2014).

1.2 Pike introduction

Prior to 2009 there were no official records of pike being present in the Owenriff catchment upstream of the natural waterfall at Canrawer, Oughterard. There are anecdotal reports suggesting that there were pike present in some lakes in the catchment in the 1990s but this was never confirmed by IFI staff and no pike were recorded in the electrofishing surveys of 1997 and 2007 (IFI unpublished data 1997; WRBD, 2008). There were also no pike recorded in the four surveys of Lettercraffroe Lough between 2007 and

2016. Gradients in excess of 6.6% (Spens *et al*., 2007) and 7% (Hein *et al*., 2011) have been shown to act as barriers to the natural dispersal of pike. The natural waterfall at Canrawer, Oughterard on the main channel of the Owenriff exceeds the published gradient threshold preventing natural colonisation of pike from the established population in Lough Corrib and therefore their recent introduction. Pike were captured for the first time by Inland Fisheries Ireland (IFI) staff in 2009 in two lakes in the catchment (Loughs Bofin and Agraffard) following reports of pike in the system. Efforts were made at that time by IFI staff to remove the pike from the system; however as the pike taken included juveniles as well as adults (up to 7kg), it seemed likely that a breeding population had become established within the system sometime previous to then.

1.3 Water quality and Water Framework Directive (WFD) ecological status

The Environmental Protection Agency monitor six sites in the Owenriff catchment every three years to assess water quality status as indicated by macroinvertebrates (Q-values); four sites are located on the main channel between Lough Agraffard and Lough Corrib and one site on the Glengawbeg Rivers. The most recent assessment (2015) indicated that the river downstream of Oughterard is Good status (Q4), while the river u/s Oughterard is high status (Q4-5). The Glengawbeg River was also assigned High (Q4-5) status in 2015.

The most recent WFD assessment of the catchment (2010 to 2015) has assigned the entire Owenriff main channel and most of its sub-catchments as Good ecological status, apart from the Glengawbeg sub-catchment and Lough Bofin which were assigned High status and Lettercraffroe lake which was assigned moderate status (EPA, 2017).

1.4 Freshwater Pearl mussel (Margaratifera margaratifera)

The Owenriff catchment is located within two different Special Areas of Conservation (SAC) both of which support two Annex II species of the E.U. Habitats Directive (92/43/EEC), namely Atlantic salmon (*Salmo salar*) and freshwater pearl mussel (*Margaratifera margaratifera*). Studies of freshwater pearl mussels in the Owenriff in the 1980's showed that there was an excellent range of ages, from juvenile to elderly, present in the catchment (NS 2, 2010). Subsequently it was also found that there was a breeding population present in the river in the mid 90's (NS 2, 2010). This species is particularly sensitive to silt, turbidity and nutrient enrichment. There was a significant loss of freshwater pearl mussels in the river in 2004 and since then the FPM population has been in decline. This was attributed

to an algal bloom and the release of phosphates from clear-felling of forestry in the Glengawbeg catchment (NS 2, 2010). A specific Sub-basin Freshwater Pearl Mussel Plan for this river catchment has been prepared to protect the FPM species (NS 2, 2010).

1.5 Channel drainage

The bed of the Owenriff main channel and a small number of tributaries draining into the lower reaches were lowered by the Office of Public works (OPW) during the 1950's and 1960's as part of the larger Corrib drainage scheme (Appendix 1). Drainage maintenance by the OPW within these channels since the original scheme has been minimal. In order to offset some of the impacts of the drainage works on fish populations IFI installed a series of low level weirs in a section of the main channel that flows through Oughterard. Over time and due to the impact of flood events, the weirs deteriorated and are now in need of repair. Also over the years, on-going works have been undertaken in order to improve fish accessibility at the waterfall in Oughterard. More recently stream development works have been carried out in sections of a small number of tributaries, namely the Bunowen and Letterfore (Plate 1).

Plate 1. Owenriff main channel low level weirs (A), Bunowen pruning (B) and Letterfore stone weirs and bank protection (C)

1.6 Fish propagation on the Owenriff River

The Oughterard Hatchery is the oldest running hatchery in the world, commencing operations in 1852 as a salmon hatchery. At the turn of the century it became a trout hatchery (supportive breeding unit) and was managed over the years by the Inland Fisheries Trust, the fishery Board and local angling clubs. Fishery. The facility is currently being operated by the Lough Corrib Angling Federation and Oughterard Angling Club and is run on a voluntary basis.

1.7 Objectives of the survey

These surveys had two main objectives:

1. Undertake a catchment wide survey of the fish stocks in the Owenriff catchment (selected lakes and rivers) to determine the current status of the fish stocks present.
2. Determine the current distribution of pike in the catchment and assess the impact, if possible, of their introduction on the fish stocks present.

This report summarises the results of the catchment wide fish stocks assessment on 17 river sites and netting surveys on two lakes. The data obtained will provide baseline information for future management of the fish stocks in the catchment.

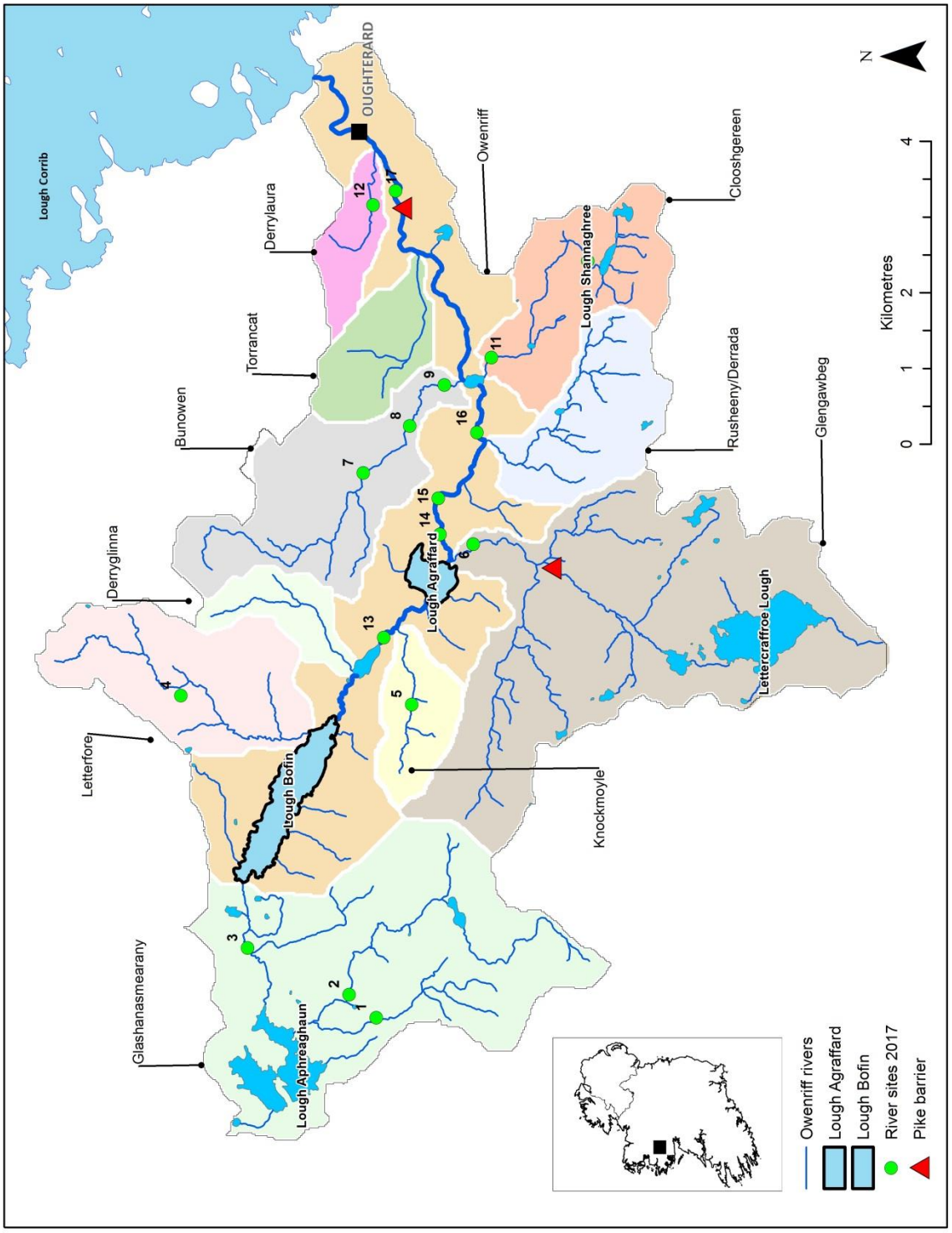


Figure 1.1 Owenriff catchment and location of electrofishing sites and lakes surveyed, 2017.

2. Study Area

The Owenriff River drains into Lough Corrib Upper downstream of Oughterard, Co. Galway (Fig. 1.1). The catchment covers an area of 6,742 hectares (67.42km^2). The underlying geology of the catchment is predominantly acidic with the exception of the segment of the Owenriff River in the vicinity of Oughterard which is dominated by lower Avonian/Carboniferous rocks. The catchment is dominated by peat soils and the most common land use within the catchment is peat bogs (64%) using the CORINE Land cover GIS layer (Table 2.1) (Lydon and Smith, 2014).

Table 2.1. CORINE land cover type for the Owenriff Catchment

Landuse type	Area (ha)	% of catchment
Peat bog	4335.8	64.3
Natural woodland / scrub	673.2	10.0
Forestry	607.1	9.0
Agriculture	376.1	5.6
Pastures	364.4	5.4
Lakes	277.2	4.1
Urban	109.1	1.6
Total	**6742.8**	**100**

There are 13 lakes in the catchment and a number of small ponds, the main lakes being, Bofin, Lettercraffroe, Loughaphreaghaun, Agraffard and Adrehid. There are ten main river sub-catchments/tributaries in the catchment (Fig. 1.1). Prior to 2007 lakes such as Lough Bofin, Lough Agraffard, Lettercraffroe Lough, Shannaghree Lough, and Loughaphreaghaun were noted as having good stocks of brown trout (O' Reilly, 2007).

There are many natural waterfalls to be found throughout the Owenriff catchment the more significant ones being those located on the Owenriff main channel at Canrawer, Oughterard, and the Glengawbeg sub-catchment at Derreighter (Fig. 1.1). Only the waterfall upstream of Derreighter is a complete barrier to salmonids. The falls at Canrawer on the main channel is a partial barrier, small grilse and smaller trout may find it difficult to ascend. Both waterfalls along with several others act as barriers to pike and other coarse fish species such as roach.

The Owenriff catchment is located within two different Special Areas of Conservation (SAC) both of which support two Annex II species of the E.U. Habitats Directive (92/43/EEC), namely Atlantic salmon (*Salmo salar*) and freshwater pearl mussel (*Margaratifera margaratifera*) (NPWS, 2005). The mid to lower Owenriff main channel and its associated tributaries fall within the Lough Corrib SAC, while the mid to upper Owenriff system, including Lettercraffroe Lough and the upper Glengawbeg system are located within the Connemara bog complex SAC, a large SAC site that encompasses a wide range of habitats, including extensive tracts of blanket bog, heath, woodland, lakes, rivers and streams (NPWS, 2005). Both lakes surveyed in 2017 are situated within the Connemara Bog Complex. The Connemara Bog Complex is underlain by various Galway granites, with small areas along the northern boundary made up of schist and gneiss (NPWS, 2005). The main perceived threats within the SAC are peat cutting, overgrazing and afforestation (NPWS, 2005).

2.1 Rivers

A total of 17 sites were electrofished as part of the Owenriff catchment survey between July 17th and 25th, 2017 (Fig. 1.1). Sites ideally contained all habitat types, including riffle, glide and pool. A suite of physical and chemical parameters were also recorded at that time.

2.1.1 Main channel

Five river sites were surveyed on the Owenriff main channel, between Oughterard village and the Quiet Man Bridge, downstream of Lough Adrehid (Table 2.1 and2.2).

2.1.2 Sub-catchments

Twelve sites were surveyed in seven sub-catchments (Fig. 1.1 and Table 2.1). Summary details for each site's location and physical characteristics are also presented (Table 2.1 and 2.2).

Table 2.1 River survey sites on the Owenriff catchment, July 2017

Code	Sub-catchment	Site name	Easting	Northing
1	Glashanasmearny	Illeny	100512	242828
2	Glashanasmearny	Cromlee Channel	100769	243198
3	Glashanasmearny	Bunnakill	101340	244440
4	Letterfore	Letterfore	104783	245369
5	Knockmoyle	Knockmoyle	104692	242352
6	Glengawbeg	Glengawbeg Br.	106756	241584
7	Bunowen	Knockbaun	107667	243041
8	Bunowen	Glengowla Br.	108366	242374
9	Bunowen	u/s L. Ateeann	108875	241987
10	Clooshgereen	Clooshgereen	110515	240043
11	Clooshgereen	Rusheeny East	109236	241306
12	Clare	Clare	111330	242891
	Main channel			
13	Owenriff	Quiet Man Br.	105582	242725
14	Owenriff	Lake Outflow	106945	241998
15	Owenriff	1 km d/s of Lough Agraffard	107328	242056
16	Owenriff	Glengowla Mine	108288	241502
17	Owenriff	D/S of Hatchery	111434	242579

Table 2.2 Physical characteristics for river sites surveyed on the Owenriff system, July 2017

Code	Sub-catchment	Site name	Mean width (m)	Surface area (m^2)	Mean depth (m)	Max depth (m)
1	Glashanasmearny	Illeny	2.14	83.46	0.10	0.25
2	Glashanasmearny	Cromlee Channel	2.06	98.88	0.18	0.36
3	Glashanasmearny	Bunnakill	3.10	135.78	0.34	0.55
4	Letterfore	Letterfore	3.43	164.80	0.16	0.56
5	Knockmoyle	Knockmoyle	2.07	75.43	0.07	0.15
6	Glengawbeg	Glengawbeg Br.	7.90	275.71	0.20	0.56
7	Bunowen	Knockbaun	3.62	146.25	0.15	0.30
8	Bunowen	Glengowla Br.	3.15	141.75	0.11	0.29
9	Bunowen	u/s L. Ateeann	3.30	145.20	0.26	0.46
10	Clooshgereen	Clooshgereen	1.07	47.17	0.25	0.51
11	Clooshgereen	Rusheeny East	3.82	129.88	0.17	0.34
12	Derrylaura	Clare	1.98	65.34	0.18	0.34
	Main channel					
13	Owenriff	Quiet Man Br.	5.03	138.19	0.55	0.80
14	Owenriff	Lake Outflow	11.58	460.69	0.32	0.65
15	Owenriff	1 km d/s of Lough Agraffard	7.00	208.60	0.24	0.63
16	Owenriff	Glengowla Mine	12.08	512.19	0.28	0.69
17	Owenriff	D/S of Hatchery	12.96	469.15	0.20	0.35

2.2 Lakes

Two lakes were surveyed in the catchment in late June/early July to assess the status of the fish stocks present.

2.2.1 Lough Bofin

Lough Bofin is a long, shallow lake located along the N59 Oughterard Maam Cross road about 10km west of Oughterard, Co. Galway on a tributary of the Owenriff River (Plate 2, Fig. 3.1). The estimated terrain elevation above sea level is 37 metres. It has a surface area of 92ha, a mean depth of <4m and a maximum depth of 14m (WRFB, 2006). The lake is categorised as typology class 2 (as designated by the EPA for the purposes of the Water Framework Directive), i.e. shallow (<4m), greater than 50ha and low alkalinity (<20mg/l CaCO3). Prior to 2007 the lake held a "fair" stock of resident brown trout, up to 3/4lb (O' Reilly, 2007). After the July floods it gets a run of Lough Corrib trout and it also holds salmon from June. Salmon are usually resident along the shore in the north-east corner and at the western end where the river flows in (O' Reilly, 2007).

Plate 2. Lough Bofin

2.2.2. Lough Agraffard

Lough Agraffard is located downstream of Lough Bofin, also along the N59 road, Co. Galway (Plate 3, Fig. 3.2). It has a surface area of 29ha, a mean depth of 2.75m and a maximum depth of 16.7m (WRBD, 2008). The lake is categorised as typology class 1 (as designated by the EPA for the purposes of the Water Framework Directive), i.e. shallow (<4m), less than 50ha and low alkalinity (<20mg/l CaCO3). The estimated terrain elevation above sea level is 37 metres. Lough Agraffard holds a resident stock of brown trout and gets a run of salmon from June onwards. The lake holds Lough Corrib trout from August on their way to the spawning grounds. Salmon are usually resident in the south-west corner where the river flows in (O' Reilly, 2007).

Plate 3. Lough Agraffard

3. Methods

3.1 Rivers – electric fishing

Electric-fishing is the method of choice to obtain a representative sample of the fish assemblage in rivers. It is a well-established technique used by fishery biologists all over the world for sampling fish in freshwaters and is generally the most non-destructive, effective and cost efficient means of sampling freshwater fish, particularly in rivers. Standard methods have been developed by IFI in compliance with the European standards for fish stock assessment in rivers (CEN, 2003 and 2005). In wadeable rivers fish sampling is normally carried out using area-delineated (ADEF) or timed electrofishing (TEF).

Fish sampling at selected river sites in the Owenriff catchment during 2017 was carried out using the TEF method.

3.1.1 TEF

For the 2017 Owenriff surveys described in this report, the TEF method was used with 10 minutes as the standard unit of time. The timed (10-minute) electrofishing method involves only two operators at a site and requires no use of stop-nets to isolate the survey stretch. Electrofishing equipment consisted of one portable generator (220/240V) with an appropriate control unit (DC converter), a cathode and an anode. Electric-fishing took place by one person wading in a zigzag manner in an upstream direction for exactly ten minutes at a steady pace (whole fishing activity).

Fish were held in buckets of fresh cold oxygenated water after they were caught until processing. . After processing they were returned to the river as soon as possible to avoid further stress. All fish were identified to species level and counted. Fish lengths and weights were taken and scales were removed from a subsample of species from each site.

Fish species abundances gathered using TEF were multiplied by the conversion factors outlined in Matson *et al*. (2017), to convert them into an equivalent “Pass 1” minimum estimate that would otherwise be calculated using the ADEF method. Minimum fish density estimates were then calculated by dividing the total abundance of each species by the surface area sampled.

3.1.2 Habitat data

An evaluation of habitat quality is critical to any assessment of ecological integrity and an assessment of habitat was performed at each survey site, with various characteristics recorded including habitat components, substrate composition and bank vegetation structure.

General physical characteristics of the site were also recorded with particular reference being made to river typology, landuse, riparian vegetation and instream features such as flow type, and substrate type. Chemical parameters recorded included water temperature and conductivity.

Wetted width and depth were also measured throughout each stretch at three transects, with five depth intervals along each. The percentage of riffle, glide and pool was also estimated in each reach surveyed.

3.2 Lakes

3.2.1 Lough Bofin netting method

Lough Bofin was surveyed over two nights from the 26th to the 28th of June 2017. A total of three sets of Dutch fyke nets (Fyke), 11 benthic monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets (BM CEN) (4 @ 0-2.9m, 4 @ 3-5.9m, 2 @ 6-11.9m and 1 @ 12-19.9m) and five four-panel benthic braided survey gill nets (4-PBB) were deployed in the lake (19 sites) (Fig. 3.1). The 4-PBB nets are composed of four 27.5m long panels each a different mesh size, tied together randomly. The gang is made up of a 55mm panel (4.25" mesh knot to knot), 60mm panel (4.75" mesh knot to knot), 70mm panel (5.5" mesh knot to knot) and a 90mm panel (7" mesh knot to knot) panel.

3.2.2 Lough Agraffard netting method

Lough Agraffard was surveyed over two nights from the 27th to the 29th of June 2017. A total of three sets of Dutch fyke nets (Fyke), eight benthic monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets (BM CEN) (2 @ 0-2.9m, 2 @ 3-5.9m, 2 @ 6-11.9m and 2 @ 12-19.9m) and 4 four-panel benthic braided survey gill nets (4-PBB) were deployed in the lake (15 sites) (Fig. 3.2).

3.2.3 Site locations

The site locations for the benthic monofilament multi-mesh gill nets (BM CEN) and the four-panel benthic braided survey gill nets (4-PBB) were chosen randomly within fixed depth zones (0-2.9m, 3-

5.9m, 6-11.9m and 12-19.9m) using available bathymetry data (Figs 3.1 and 3.2). A handheld GPS was used to mark the precise location of each net. The angle of each gill net in relation to the shoreline was also randomised.

All fish were measured and weighed on site and scales were removed from all brown trout and pike. Live fish were returned to the water whenever possible (i.e. when the likelihood of their survival was considered to be good). Samples of fish were retained for further analysis.

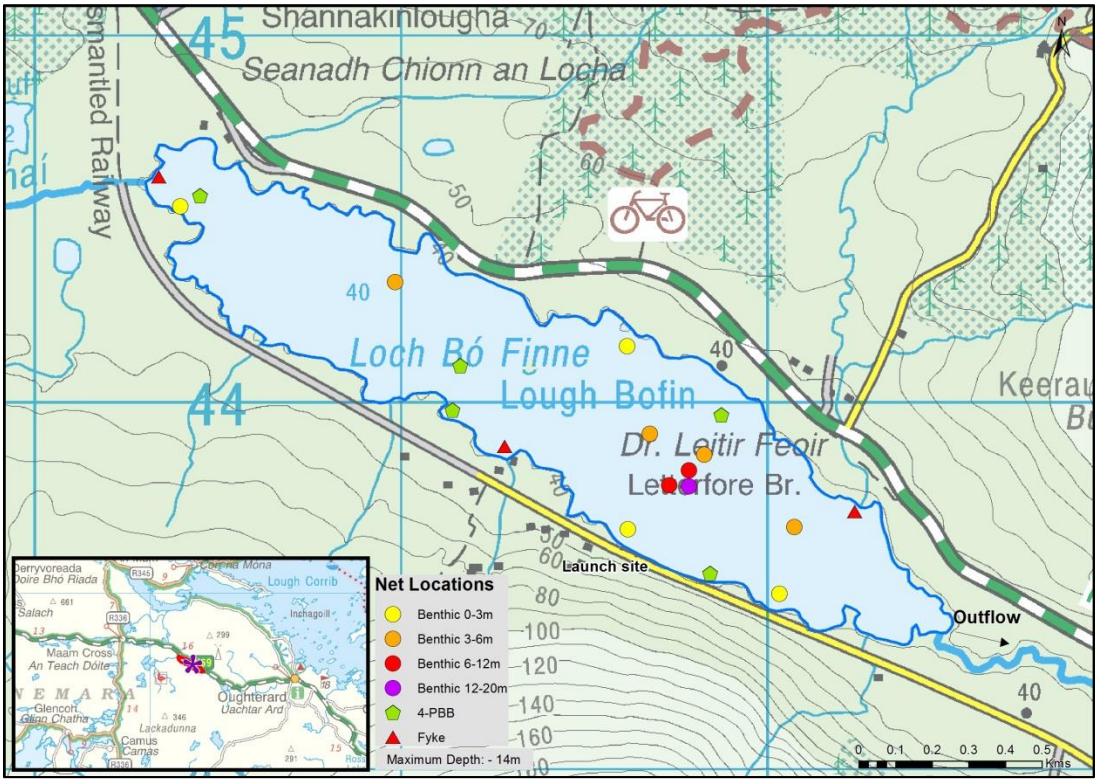


Fig. 3.1. Location map of Lough Bofin showing net locations and depths of each net (outflow is indicated on map)

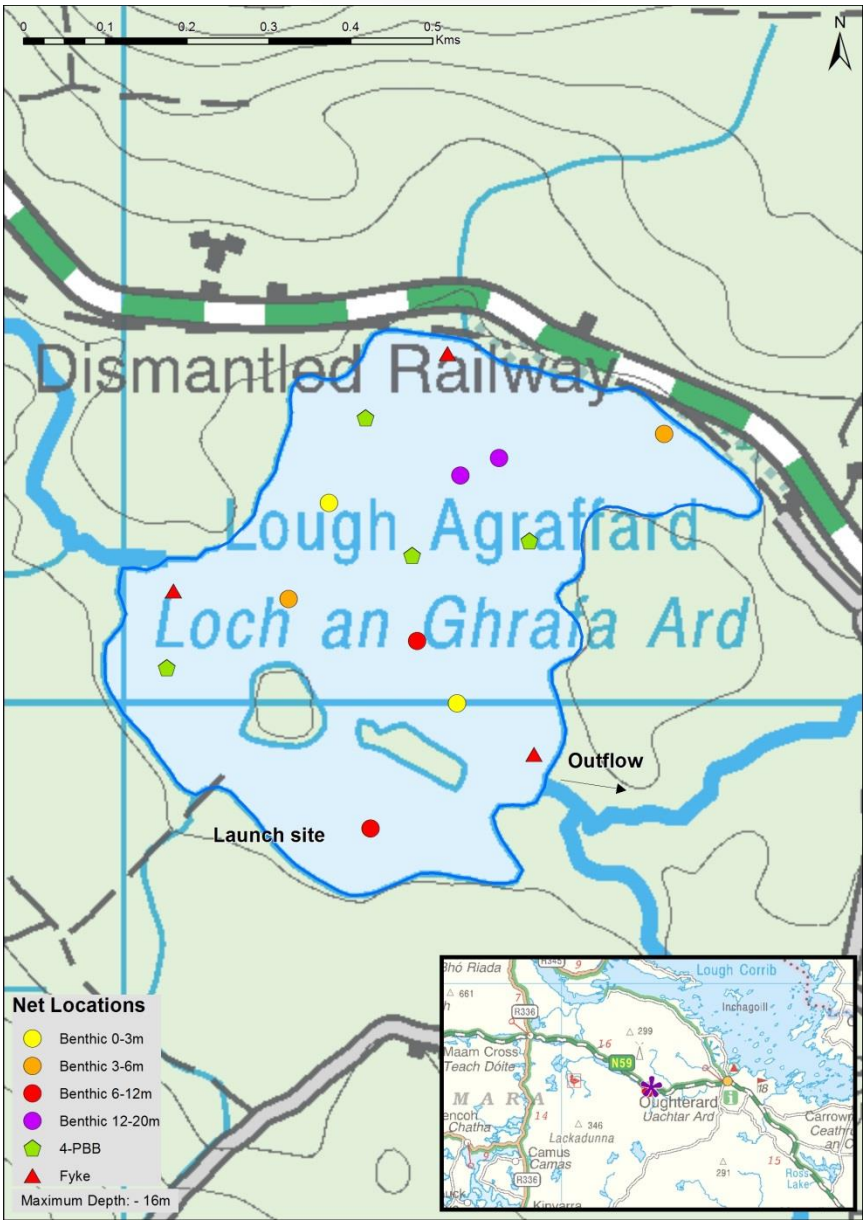


Fig. 3.2. Location map of Lough Agraffard showing net locations and depths of each net (outflow is indicated on map)

3.2.4 Fish diet

Fish samples from the lake surveys were either dissected in the field and their entire stomach contents preserved in 97% ethanol or the whole fish were frozen and returned to the IFI laboratory where they were dissected. The stomach contents of all fish dissected were identified to the lowest taxonomic level.

For both pike and trout, the percentage frequency occurrence (%O) of prey items were then calculated to identify key prey items (Amundsen *et al.*, 1996).

$$\%O_i = \left(\frac{N_i}{N}\right) * 100$$

Where:

- $\%O_i$ is the percentage frequency of prey item i,
- N_i is the number of a particular species with prey i in their stomach,
- N is total number of a particular species with stomach contents.

For pike stomach content analysis, fish-prey were identified, enumerated and each individual prey item weighed to the nearest 0.001g. Invertebrate prey were enumerated and assigned to an appropriate taxonomic level and the combined weight of all prey within each group was determined for each stomach. Prey species, numbers of prey and prey weight were thus available for each stomach examined.

In addition to %O, several indices of dietary importance were calculated for pike. These were:

- % Number (% N). The proportional numeric contribution of individual prey species/groups ($_i$) to the overall prey numbers in the diet.
  - $\%N_j = \frac{N_i}{(N_i + N_{ii} + N_{iii} \ldots)} * 100$
- % Biomass (% W). The proportional contribution of each prey species/group ($_i$) combined weight expressed as a percentage of the total biomass of all prey in the diet.
  - $\%W_i = \frac{W_i}{(W_i + W_{ii} + W_{iii} \ldots)} * 100$

To reduce the potential bias inherent in the use of single dietary metrics, the Index of Relative Importance (IRI) was calculated from each prey item/group by combining %N and %W with % O (Pinkas and Iverson, 1971).

$$IRI_j = (\%N + \%W) * \%O$$

To improve the comparison of the importance of different prey types %IRI was calculated for each prey item/group ($_i$) in the diet (Cortés, 1997).

$$\%IRI_j = \frac{IRI_j}{(IRI_i + IRI_{ii} + IRI_{iii} \ldots\ldots)} * 100$$

3.3 Other methods

3.3.1 Fish processing, age and growth

All fish species present were recorded at all sites (rivers and lakes) surveyed. All brown trout and pike were aged. Fish scales were read using a microfiche reader. Growth was determined by back-calculating lengths at the end of each winter using the following formula:

$$Ln = \left(\frac{Sn}{S}\right) * L$$

Where:

Ln= length of fish when annulus "n" was formed

l= length of fish when scale sample was taken

Sn = radius of annulus "n" (at fish length Ln)

S = total scale radius

3.3.2 Data analysis

Fish abundance is presented as (minimum) population estimates (number of fish/m^2) for river sites. For lakes fish abundance (mean CPUE) and biomass (mean BPUE) were calculated as the mean number/weight of fish caught per metre of net. For all fish species except eel, CPUE/BPUE is based on all nets, whereas eel CPUE/BPUE is based on fyke nets only.

Where appropriate, data from previous surveys conducted both within the Owenriff catchment and in catchments with similar environmental characteristics conducted prior to 2017 is presented for comparative purposes.

3.4 Fish ecological status

3.4.1 Rivers

An ecological classification tool for fish in rivers (Fisheries Classification Scheme 2 (FCS2-Ireland)) was developed in 2011 to assign ecological status to fish in rivers for the Republic of Ireland and Northern Ireland along with a separate version for Scotland (SNIFFER, 2011). FCS2-Ireland is a geostatistical model based on Bayesian probabilities and works by comparing various fish community metric values within a site (observed) to those predicted (expected) for that site under reference (un-impacted) condition. The resulting output is an Ecological Quality Rating (EQR) between 1 and 0 for each site, corresponding to the five different ecological status classes of High, Good, Moderate, Poor and Bad (SNIFFER, 2011). Confidence levels are then assigned to each class and represented as probabilities. The tool has been successfully inter-calibrated in a cross-Europe exercise (EC, 2013).

All outputs of the tool are sense-checked annually by experienced users. Using this tool and expert opinion, each river site surveyed on the Owenriff River system was assigned a draft fish classification status.

3.4.2 Lakes

A multimetric fish in lakes ecological classification tool (Fish in Lakes – 'FIL') was developed for the island of Ireland (Ecoregion 17) using IFI and Agri-Food and Biosciences Institute Northern Ireland (AFBINI) data generated during the NSSHARE Fish in Lakes project (Kelly *et al.*, 2008). This tool was further developed during 2010 (FIL2) in order to make it fully WFD compliant, including producing EQR values for each lake and associated confidence in classification (Kelly *et al*., 2012). FIL2 was also successfully intercalibrated in a cross-Europe Exercise (EC, 2013). Using this tool and expert opinion, each lake surveyed in the catchment was assigned a draft fish classification status.

3.5 Quality Assurance

CEN (2005) recommends that all activities undertaken during the standard fish sampling protocol (e.g. training, handling of equipment, fish handling, fish identification, etc.) should be subjected to a quality assurance programme in order to produce consistent results of high quality. A number of quality control procedures were implemented for the current programme, for example; every tenth fish scale was checked in the laboratory by a second biologist experienced in age analysis techniques.

3.6 Biosecurity and decontamination procedures

Procedures are required for disinfection of equipment in order to prevent dispersal of alien species and other organisms to uninfected waters. A standard operating procedure was compiled by Inland Fisheries Ireland for this purpose (Caffrey, 2010) and was followed by staff undertaking the survey on the Owenriff catchment.

4. Results

4.1 Rivers

4.1.1 Glashanasmearany sub-catchment

Three sites were surveyed in the Glashanasmearany sub-catchment on the 25th of July 2017 (Fig. 1.1). The area of the Glashanasmearany catchment is approximately 12.4km^2. The system comprises of the Derrygauna and Sruffaunboy rivers which flow into Loughaphreaghaun and the outflowing Glashanasmearany River, which flows in an easterly direction into the western end of Lough Bofin (Fig 1.1). The underlying geology is mixed, but mainly schist and granite. The primary land use is forestry on the north-western end of the catchment and blanket bog on the southern and eastern end. The majority of this catchment falls within the Connemara Bog Complex SAC. Plate 4 shows one of the survey sites at Bunnakill (Site 3).

Brown trout were recorded in the two upper sites (sites 1 & 2) along with pike and minnow. While no salmon were noted on this occasion in any of the three sites surveyed, salmon were recorded in this area during a previous survey in 2007 (WRFB, 2008). Brown trout densities were poor with only 0+ juveniles noted, ranging in length from 5 cm to 7.5 cm. Three pike, ranging in length from 10 cm to 20 cm, were also present and aged from 0+ to 1+. No salmonids were recorded at site 3 (Bunnakill) on the Glenshanasmearany River, downstream of Loughaphreaghaun. Minnow were the only fish species encountered at the site. Both salmon and brown trout were recorded at this location during the 2007 survey albeit in small numbers (WRFB, 2008).

Table 4.1. Minimum density of fish (no. /m^2), Glashanasmearany sub-catchment

	Minimum density		
Species	**Site 1 Illeny**	**Site 2 Cromlee**	**Site 3 Bunnakill**
Brown trout	0.0479	0.0607	-
0+ brown trout	0.0479	0.0607	-
1+ & older brown trout	-	-	-
Minnow	-	0.0303	0.0221
Pike	0.0240	0.0101	-
All Fish	**0.0719**	**0.1011**	**0.0221**

Plate 4. Glashanasmearany sub-catchment at Illeny (Site 1, Sruffaunboy Stream), Cromlee (Site 2, Derrygauna Stream) and Bunnakill (Site 3), 2017

4.1.2 Letterfore sub-catchment

One site was surveyed on the Letterfore River on the 18th of July 2017 (Fig. 1.1 and Plate 5). The area of the Letterfore catchment is approximately 5km^2. The Letterfore stream flows in a southerly direction draining into Lough Bofin at Letterfore Bridge (Fig 1.1). The underlying geology is mixed, comprising of granite on the western side of the catchment and schist to the east. Landuse consists of forestry, blanket bog and pasture. A small portion of this catchment falls within the Connemara Bog Complex SAC, towards the lower end of the channel and down to its confluence with Lough Bofin (Fig. 1.1).

Plate 5. Letterfore sub-catchment at Letterfore (Site 4), 2017

The Letterfore site was located in the upper reaches of the Letterfore River within a section that forms part of a diverted channel. The level of bank erosion throughout this high energy section is extensive and in recent years has undergone bank protection work along with the addition of stone weirs and pools (Plate 5). Both salmon and brown trout were present at the site but their densities were relatively low (Table 4.2). Fish ranged in length from 10 cm to 13cm and were all 1+ year old fish. Historically this river would have been considered a productive juvenile salmon river (IFI unpublished data 1997; WRFB, 2008).

Table 4.2. Minimum density of fish (no./m^2), Letterfore sub-catchment

	Minimum density
Species	**Site 4 Letterfore**
Brown trout	0.0243
0+ brown trout	-
1+& older brown trout	0.0243
Salmon	0.0121
0+ salmon	-
1+ & older salmon	0.0121
All Fish	**0.0364**

4.1.3 Knockmoyle sub-catchment (Leam River)

One site was surveyed on the Knockmoyle River on the 17th of July 2017 (Fig. 1.1 and Plate 6). The area of the Knockmoyle catchment area is approximately 1.75km^2. This small tributary joins the Owenriff main channel between Lough Adrehid and Lough Agraffard where the old dismantled railway used to cross the river (Fig 1.1). The underlying geology of this sub-catchment is mostly schist. The main land use for this catchment is peat bog/scrubland and pasture.

Plate 6. Knockmoyle sub-catchment at Knockmoyle (Site 5), 2017

Brown trout were the only fish species encountered at this site (Table 4.3). Fish ranged in size from 5.5cm to 11.5cm with the majority classed as 0+ fish. Historically this channel would have been considered an excellent brown trout spawning river with some salmon recorded (IFI unpublished data, 1997). In more recent years brown trout numbers have declined (WRFB, 2008).

Table 4.3. Minimum density of fish (no. /m^2), Knockmoyle sub-catchment

Species	Minimum Density Site 5 Knockmoyle
Brown trout	0.3049
0+ brown trout	0.2724
1+ & older brown trout	0.0280
All Fish	0.3049

4.1.4 Glengawbeg sub-catchment

One site was surveyed on the Glengawbeg River on the 18th of July 2017 (Fig. 1.1 and Plate 7). The area of the Glengawbeg catchment is approximately 15km^2. The Glengawbeg River flows in a northerly direction draining two lakes, Lettercraffroe Lough and Lough Acogga before joining the Owenriff River just downstream of Lough Agraffard (Fig 1.1). The underlying geology is mixed between granite, gneiss and schist. Forestry and peat bog covers most of this catchment. The upper and western reaches of this catchment fall within the Connemara Bog Complex SAC (Fig. 1.1).

Plate 7. Glengawbeg sub-catchment at Glengawbeg Br. (Site 6), 2017

There are a number of small and one large natural waterfall within this sub-catchment. The falls located at Derryeighter (Plate 8) is the largest of these and while it is impassable to pike (gradient > 7%) it is not completely impassable to salmonids, though would be classed as difficult. Salmon are present in the Derryeighter tributary which is located above these falls. However, salmon are not known to travel further upstream of this tributary.

Plate 8. Natural waterfall on the Glengawbeg, at Derreighter, 2017

Both salmon and brown trout were recorded at this site though salmon were the more prevalent of the two, as was the case for the previous two surveys of the Glengawbeg River (IFI unpublished data, 1997; WRFB, 2008). Only the 0+ age cohort of brown trout was present at the site and these ranged in length from 4cm to 5cm. Both 0+ and 1+ salmon were present and ranged in length from 3.4cm to 7.1cm (Table 4.4). Small numbers of minnow were also present.

Table 4.4. Minimum density of fish (no. /m^2), Glengawbeg sub-catchment

	Minimum Density
Species	**Site 6 Glengawbeg Br.**
Brown trout	0.0109
0+ brown trout	0.0109
1+ & older brown trout	-
Minnow	0.0290
Salmon	0.1161
0+ salmon	0.1088
1+ & older salmon	0.0073
All Fish	**0.1560**

4.1.5 Bunowen sub-catchment

Three sites were surveyed on the Bunowen River between the 18th and 25th of July 2017 (Fig. 1.1 and Plate 9). The area of the Bunowen sub-catchment is approximately 5.4km^2. This river flows in a south-easterly direction towards Glengowla, joining the main Owenriff system at Lough Ateeann (Fig 1.1). The underlying geology is typically granite and schist. The land use is mainly composed of blanket bog, with forestry towards the uppermost reaches. Pockets of scrub and rough pasture also exist within the mid-reaches. A large portion of this channel's lower section and banks are located within the Lough Corrib SAC (NPWS, 2005).

Plate 9. Bunowen sub-catchment at Knockbaun (Site 7), Glengowla Br. (Site 8) and Glengowla ford (Site 9), 2017

Brown trout were present at all three sites while salmon were only recorded at Glengowla Bridge (Site 8) (Table 4.5). Brown trout ranged in length from 3.5cm to 17.2cm and salmon from 3.2cm to 9.5cm. The majority of salmonids recorded were 0+ fish (Table 4.5).

Table 4.5. Minimum density of fish (no. /m^2), Bunowen sub-catchment

	Minimum Density		
Species	**Site 7 Knockbaun**	**Site 8 Glengowla Br.**	**Site 9 u/s L. Ateeann**
Brown trout	0.4376	0.2610	0.1928
0+ brown trout	0.2803	0.1481	0.1791
1+ & older brown trout	0.1573	0.1199	0.0138
Salmon	-	0.3104	-
0+ salmon	-	0.2399	-
1+ & older salmon	-	0.0705	-
All Fish	0.4376	0.5714	0.1928

4.1.6 Clooshgereen sub-catchment (Rusheeny East)

Two sites were surveyed on the Clooshgereen River (Rusheeny) on the 24th of July 2017 (Fig. 1.1 and Plate 10). The area of the Clooshgereen sub-catchment is approximately 4.1km^2. This river flows in a north-westerly direction, draining a series of lakes, Lough Tawny, Shannaghree Lough and Lough Beg, before reaching the main Owenriff system at Lough Ateeann (Fig 1.1). The underlying geology is predominantly schist and gneiss. Landuse is mainly scrub and blanket bog to the south and west and farmland towards the north-east and confluence with Lough Ateeann. A small portion of this catchment, towards the lower end and Lough Ateeann confluence is within the Lough Corrib SAC (NPWS, 2005).

Plate 10. Clooshgereen sub-catchment at Clooshgereen (Site 10) and Rusheeny East (Site 11) and 2017

Brown trout were recorded at both sites while salmon were only captured at the lower site (Rusheeny East site 11) (Table 4.6). Lengths of trout ranged from 6.8cm to 12.5cm and salmon were in the 10cm length category. Densities of both species were generally poor. Whereas in the previous 2007 survey greater numbers of salmon were noted with the exception of the upper site at Rusheeny East (immediately downstream of Shannaghree Lough) where no salmon were recorded. During the 1997 survey (IFI unpublished data, 1997) even greater densities of salmon and trout were recorded.

Table 4.6. Minimum density of fish (no. /m^2), Clooshgereen sub-catchment

Species	Minimum Density	
	Site 10 Clooshgereen	Site 11 Rusheeny East
Brown trout	0.1272	0.0539
0+ brown trout	0.0848	0.0385
1+ & older brown trout	0.0424	0.0154
Salmon	-	0.0308
0+ salmon	-	-
1+ & older salmon	-	0.0308
All Fish	**0.1272**	**0.0847**

4.1.7 Derrylaura sub-catchment (Byrne's River)

One site was surveyed on the Derrylaura stream (Byrne's stream) on the 18th of July 2017 (Fig.1.1 and Plate 11). The area of the Derrylaura sub-catchment is approximately 1.3km^2. This small river flows eastwards towards the main Owenriff channel joining it in Oughterard. It flows underground for approximately 300m (Fig 1.1). The underlying geology of this catchment differs from the greater Owenriff catchment, being comprised of more calcareous rock types including shale, limestone and sandstone. The land use here is predominantly farmland and pasture, with significant portions also used for urban developments and housing estates.

Plate 11. Derrylaura sub-catchment at Clare townland (site 12), 2017

Only brown trout were recorded at the site, salmon do not seem to pass through the underground section of this river which starts at the confluence with the Owenriff main channel and extends upstream for approximately 300m, they were also not recorded during the 1997 survey (Table 4.7) (IFI unpublished data, 1997). Brown trout ranged in length from 3.9cm to 15.8cm and included four age classes, 0+, 1+, 2+ and 3+. Fish of 15cm and greater were determined to be 3+ years old, which would be indicative of very slow growth (Kelly *et al*., 2017).

Table 4.7. Minimum density of fish (no. /m^2), Derrylaura sub-catchment

Species	Minimum Density Site 12 Clare
Brown trout	0.5510
0+ brown trout	0.2908
1+ & older brown trout	0.2602
All Fish	**1.3157**

4.1.8 Owenriff main channel

Five sites were surveyed on the Owenriff main channel between the 17th and 24th of July 2017 (Fig. 1.1 and Plate 12). The area of the Owenriff River sub-catchment is approximately 15.4km^2. This river enters Upper Lough Corrib, just east of Oughterard (Fig 1.1). The underlying geology consists largely of siliceous rock formations including granite, gneiss and schist, with only a small portion of calcareous rock towards the Derrylaura sub-catchment and the river's confluence with Lough Corrib. The primary land uses within this catchment are blanket bog and scrubland, with significant portions used for forestry and farmland (low intensity livestock/pasture). Urban development is restricted mainly to Oughterard at the very lower end of the catchment. Two SAC's overlap with the Owenriff catchment, the Connemara Bog Complex at the western end and the Lough Corrib SAC, from Lough Agraffard along the main channel towards the Lough Corrib confluence.

Of the five sites surveyed salmon were recorded at four sites and trout at three (Tables 4.8 and 4.9). Pike were the only fish species recorded at site 13. Salmon were dominant at all sites where salmonids were present with the greatest densities noted at site 15 (2017 survey), followed by site 17 (Tables 4.8 and 4.9). Brown trout densities were poor across all sites surveyed along the main Owenriff channel. Brown trout densities decreased at site 15 between 2010 and 2017 (Table 4.9). Brown trout 1+ & older were not recorded at this site in the latter two surveys in 2015 and 2017 (Table 4.9). Salmon ranged in length from 3cm to 11.8cm and were aged between 0+ and 2+. In general 0+ salmon were more abundant than 1+ and older fish. Minnow were also present at three of the five sites (Table 4.8 and 4.9).

Plate 12. Owenriff main channel at Quiet Man Bridge (Site 13), Lake Outflow (Site 14), 1 km d /s of Lough Agraffard (Site 15), Glengowla Mine (Site 16) and D/S of Hatchery (Site 17), July 2017

Table 4.8. Minimum density of fish (no. /m^2), Sites 13, 14, 16 and 17, Owenriff sub-catchment, July 2017

Species	Minimum Density			
	Site 13 Quiet Man Br. 2017	Site 14 Lake Outflow 2017	Site 16 Glengowla Mine 2017	Site 17 D/S of Hatchery 2017
Brown trout	-	0.0043	-	0.0234
0+ brown trout	-	0.0043	-	0.0234
1+ & older brown trout	-	-	-	-
Minnow	-	0.0217	0.0059	-
Pike	0.0072	-	-	-
Salmon	-	0.0543	0.0527	0.1790
0+ salmon	-	0.0456	0.0488	0.0895
1+ & older salmon	-	0.0087	0.0039	0.0895
All Fish	**0.0072**	**0.0803**	**0.0586**	**0.2025**

Table 4.9. Minimum density of fish (no./m2), Site 15, Owenriff sub-catchment, 2010, 2015 and 2017

Species	Minimum Density		
	Site 15 1 km d/s of Lough Agraffard		
	2010	2015	2017
Brown trout	0.0131	0.0114	0.0096
0+ brown trout	0.0033	0.0114	0.0096
1+ & older brown trout	0.0098	-	-
Minnow	0.1540	0.0285	0.0431
Pike	-	0.0029	-
Salmon	0.1311	0.3050	0.2780
0+ salmon	0.0819	0.2879	0.1918
1+ & older salmon	0.0492	0.0171	0.0863
All Fish	**0.2983**	**0.3478**	**0.3308**

4.1.9 Age, length frequency and growth rate

Brown trout, from across the Owenriff catchment, ranged in length from 3.5cm to 17.2cm (Fig. 4.1). Most brown trout (75%) were within the 0+ age class (Fig. 4.2). Only two 2+ and one 3+ brown trout were encountered across the 17 sites (Fig. 4.2). The 3+ specimen was recorded on the Derrylaura stream at Clare townland (Site 12), while the largest brown trout was caught on the Bunowen River at the Glengowla bridge site (Site 8), measured 17.2cm in length and was aged 2+.

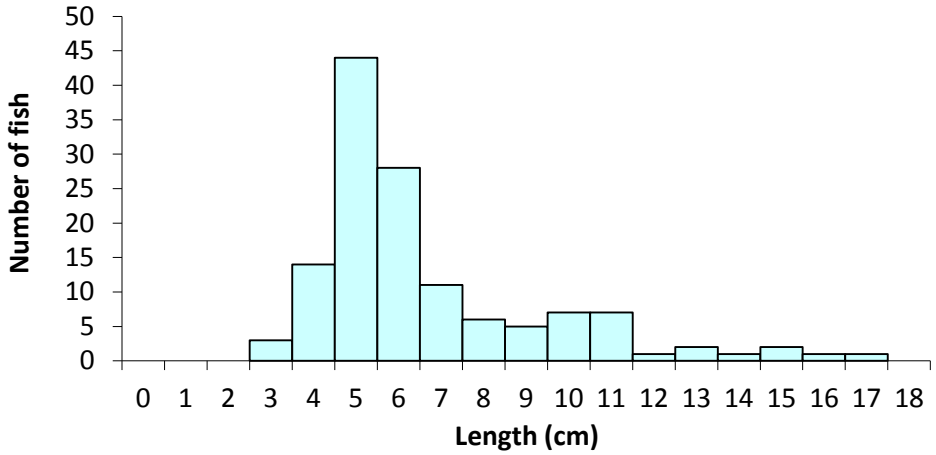


Fig. 4.1. Length frequency distribution of brown trout in the Owenriff system (all sites combined), 2017 (n=133)

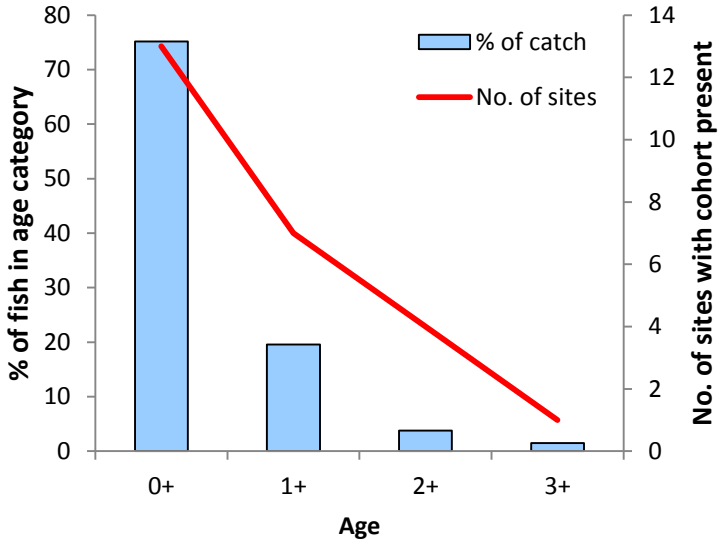


Fig. 4.2. Brown trout age composition and number of sites where they were recorded

Four pike were recorded during the 2017 river survey. Three of these pike were aged 1+, with only one aged 0+ (Fig. 4.3). The largest measured 26.5cm, weighed 117g and was aged at 1+.

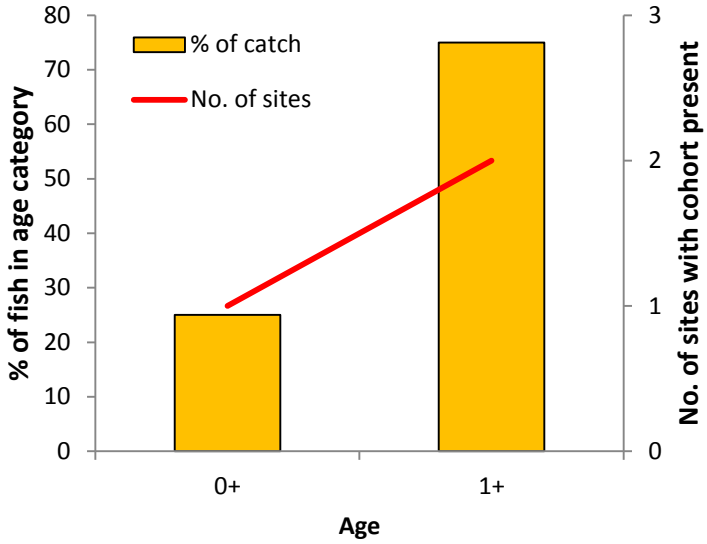


Fig. 4.3. Pike age composition and number of sites where they were recorded

Salmon ranged in length from 3cm to 11.8cm across all the sites surveyed in 2017 (Fig. 4.4). Three age classes of salmon were recorded, with 0+ the most abundant cohort (Fig. 4.5). Salmon aged 1+ and 2+ were recorded at only two and one site respectively. The largest salmon encountered measured 11.8cm, weighed 21.5g and was aged 2+.

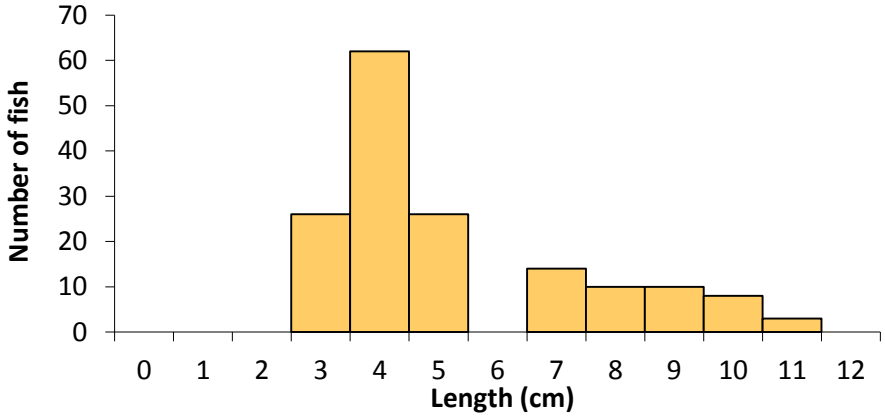


Fig. 4.4. Length frequency distribution of salmon in the Owenriff system, 2017 (n=159)

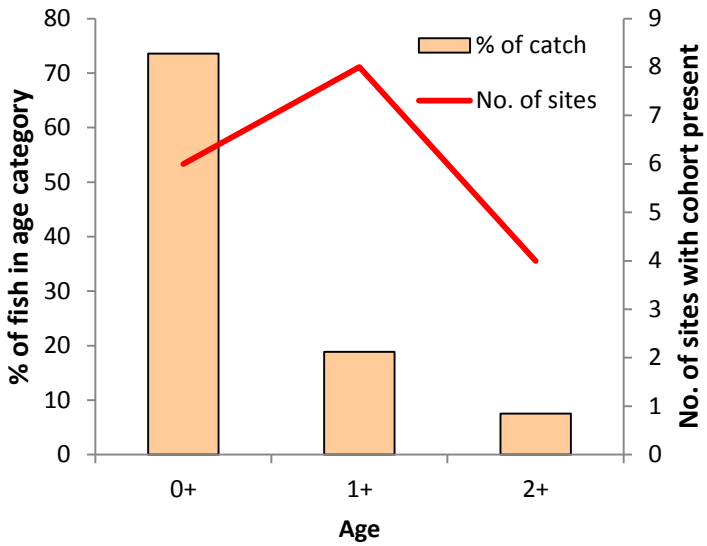


Fig. 4.5. Salmon age composition and number of sites where they were recorded

The mean back-calculated length-at-age data for brown trout, where individuals aged 1+ and older were recorded is shown below in Fig. 4.10. The growth rate of brown trout was determined using Table 4.11 below and was deemed to be slow.

The mean back-calculated length-at-age data for pike, where individuals aged 1+ and older were recorded is shown below in Fig. 4.10.

The mean back-calculated length-at-age data for salmon, where individuals aged 1+ and older were recorded is shown below in Fig. 4.10.

Table 4.10. Summary of brown trout, pike and salmon growth in rivers (L1=back calculated length (cm) at the end of the first winter etc.)

Salmon		L1	L2	L3	Growth rate
Brown trout	Mean	5.48	10.22	13.27	SLOW
	S.D.	1.42	2.03	0.57	
	n	32	7	2	
	Min	3.47	7.49	12.86	
	Max	8.87	12.89	13.67	
Pike	Mean	12.50			n/a
	S.D.	3.82			
	n	3			
	Min	8.45			
	Max	18.41			
Salmon	Mean	4.17	7.43		n/a
	S.D.	1.24	1.02		
	n	29	11		
	Min	2.31	5.50		
	Max	8.29	9.33		

Table 4.11. Length at age limits for each growth category of brown trout in rivers (Kelly *et al.*, 2017)

Growth Category	L1 (cm)	L2 (cm)	L3 (cm)	L4 (cm)
Very Slow	<5	<10	<14.5	<20
Slow	5 to 5.5	10 to 12	14.5 to 18	20 to 24
Moderate	5.5 to 9	12 to 18.5	18 to 24.5	24 to 32
Fast	9 to 10	18.5 to 21.5	24.5 to 29.5	32 to 36.5
Very Fast	>10	>21.5	>29.5	>36.5

4.1.10 Community structure and distribution

Salmon and brown trout were the two most frequently encountered and abundant fish species recorded across the 17 sites in the Owenriff catchment during 2017. In total only four fish species were recorded during the survey (Table 4.12). Brown trout was the most common fish species recorded, occurring in 14 sites, followed by salmon (8 sites), minnow (6 sites) and pike (3 sites) (Table 4.12).

Owenriff main channel

Five sites (Sites 13 to 17) were sampled on the main Owenriff River during 2017 (Fig. 1.1). Site 15 is a WFD surveillance monitoring site and has been surveyed on two previous occasions (2010 and 2015). Brown trout were only recorded on three of the main channel sites during 2017 (Fig. 4.6). Densities of brown trout in the main channel were low. The highest density (0.023 fish/m^2) of 0+ brown trout was recorded at Site 17 (d/s of Hatchery (Fig. 4.6). No 1+ and older trout were recorded at any of the main channel sites surveyed in 2017; however they were recorded (0.010 fish m^2) at Site 15 (1km d/s of Lough Agraffard) in 2010 (Table 4.9).

Salmon were recorded at all main channel sites (Fig. 4.6), except for Site 13 (Quiet Man Br.); this site was composed of deeper water, with no riffle habitat present. The highest density of salmon (0.278 fish/m^2) was recorded at Site 15 (1km d/s of Lough Agraffard); although this was lower than in 2015 when the density was (0.305 fish/m^2). Site 15 also had the highest density of salmon fry (0+) (Fig. 4.6). The greatest densities of 1+ and older salmon (0.0865 fish/m^2 and 0.0863 fish/m^2respectively) were recorded at Site 17 (d/s of Hatchery) and Site 15 (1km d/s of Lough Agraffard) (Fig. 4.6).

Minnow were recorded at three sites in 2017; their greatest density (0.043 fish/m^2) was encountered at Site 15 (1km d/s of Lough Agraffard). Pike were only encountered at one site on the main channel in 2017 (Site 13, Quiet Man Br.). This was a single individual (0.007 fish/m^2) and the only fish species recorded at the site. A single pike (0.029 fish/m^2) was also recorded at Site 15 (1km d/s of Lough Agraffard) in 2015.

Owenriff tributaries

Of the 12 tributary sites sampled in 2017, brown trout were encountered at 11, their highest density recorded at Site 12 (Clare – Derrylaura sub-catchment) (0.551 fish/m^2). Brown trout fry (0+) were present at 10 sites while older brown trout (1+ and older) were encountered in eight sites (Fig. 4.6 and 4.8). The highest densities recorded for 0+ (0.291 fish/m^2) and 1+ and older brown trout (0.260 fish/m^2) were both recorded at Site 12 (Clare) (Fig. 4.6).

Salmon were encountered at only four of the tributary sites, with their highest density (0.310 fish/m^2) recorded at Site 8 (Glengowla Br.) (Fig. 4.6 and 4.10). Salmon fry (0+) were only present at two sites while salmon 1+ and older were encountered at four sites (Fig. 4.6 and 4.10). The highest densities recorded for 0+ salmon (0.240 fish/m^2) and 1+ and older salmon (0.071 fish/m^2) were both recorded at Site 8 (Glengowla Br.) (Fig. 4.6).

Minnow were recorded at three tributary sites with their greatest density (0.030 fish/m^2) recorded at Site 2 (Cromlee Channel). Pike were captured at two tributary sites (Fig. 4.11) with their highest density (0.024 fish/m^2) recorded at Site 1 (Illeny).

Table 4.12. List of fish species recorded in the 17 Owenriff sites surveyed during 2017

	Species name & age cohort	Common name	Number of river sites	% of river sites
1	Brown trout	*Salmo trutta fario*	14	82.4
	0+ brown trout		13	76.5
	1+ & older brown trout		8	47.1
2	Salmon	*Salmo salar*	8	47.1
	0+ salmon		6	35.3
	1+ & older salmon		8	47.1
3	Minnow	*Phoxinus phoxinus*	6	35.3
4	Pike	*Esox lucius*	3	17.6

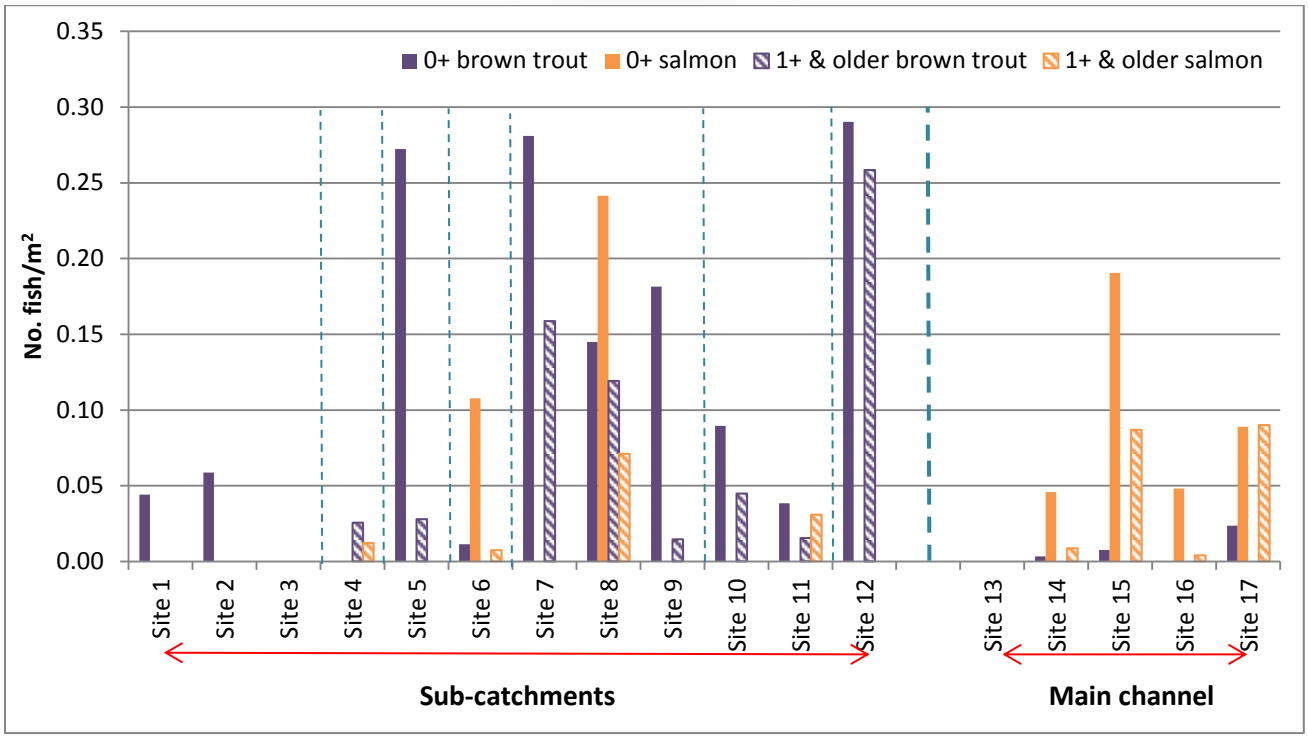


Fig. 4.6: Minimum densities of brown trout and salmon at Sites 1 to 17, Owenriff catchment 2017.

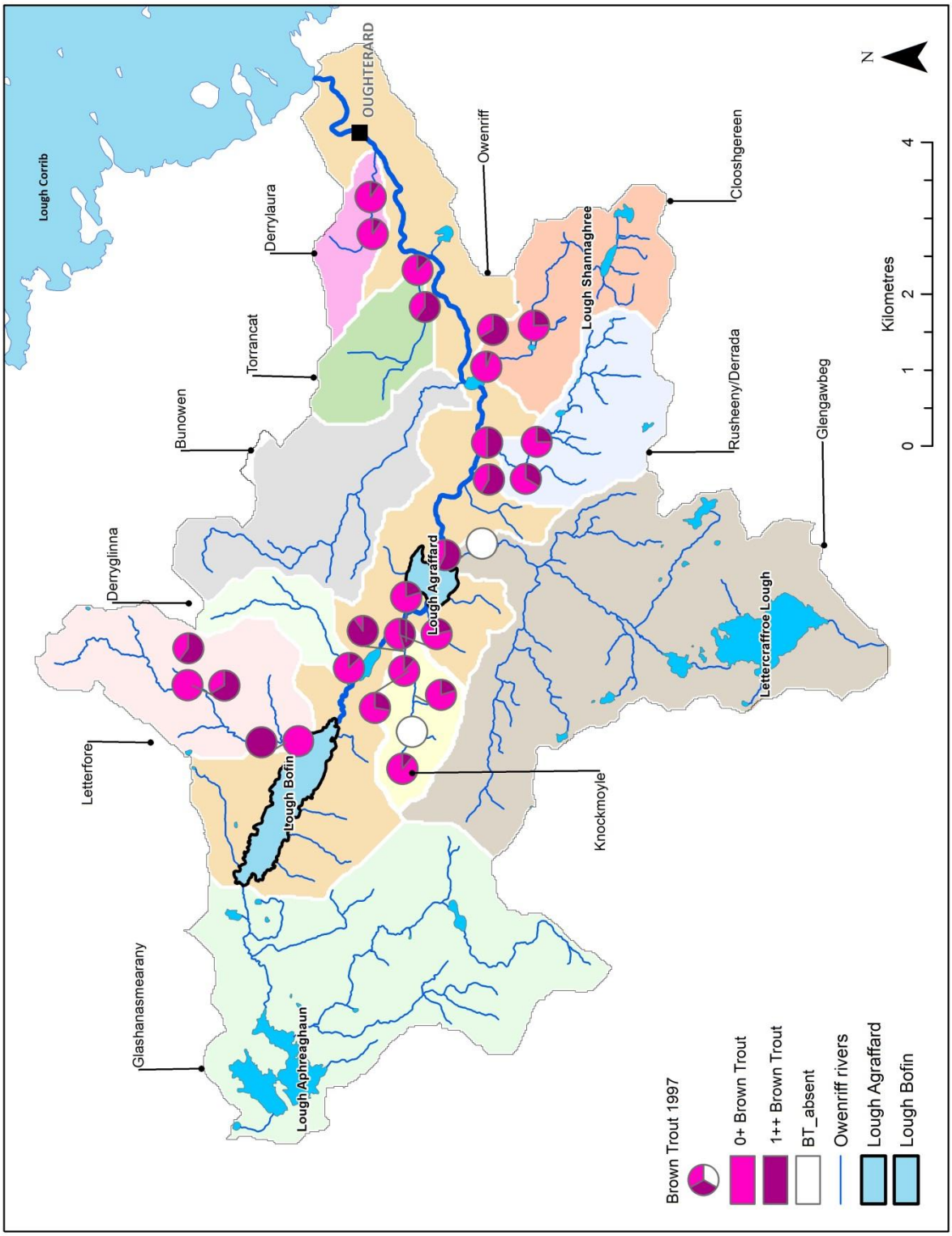


Fig. 4.7. Presence and absence of brown trout at river sites, Owenriff catchment, 1997

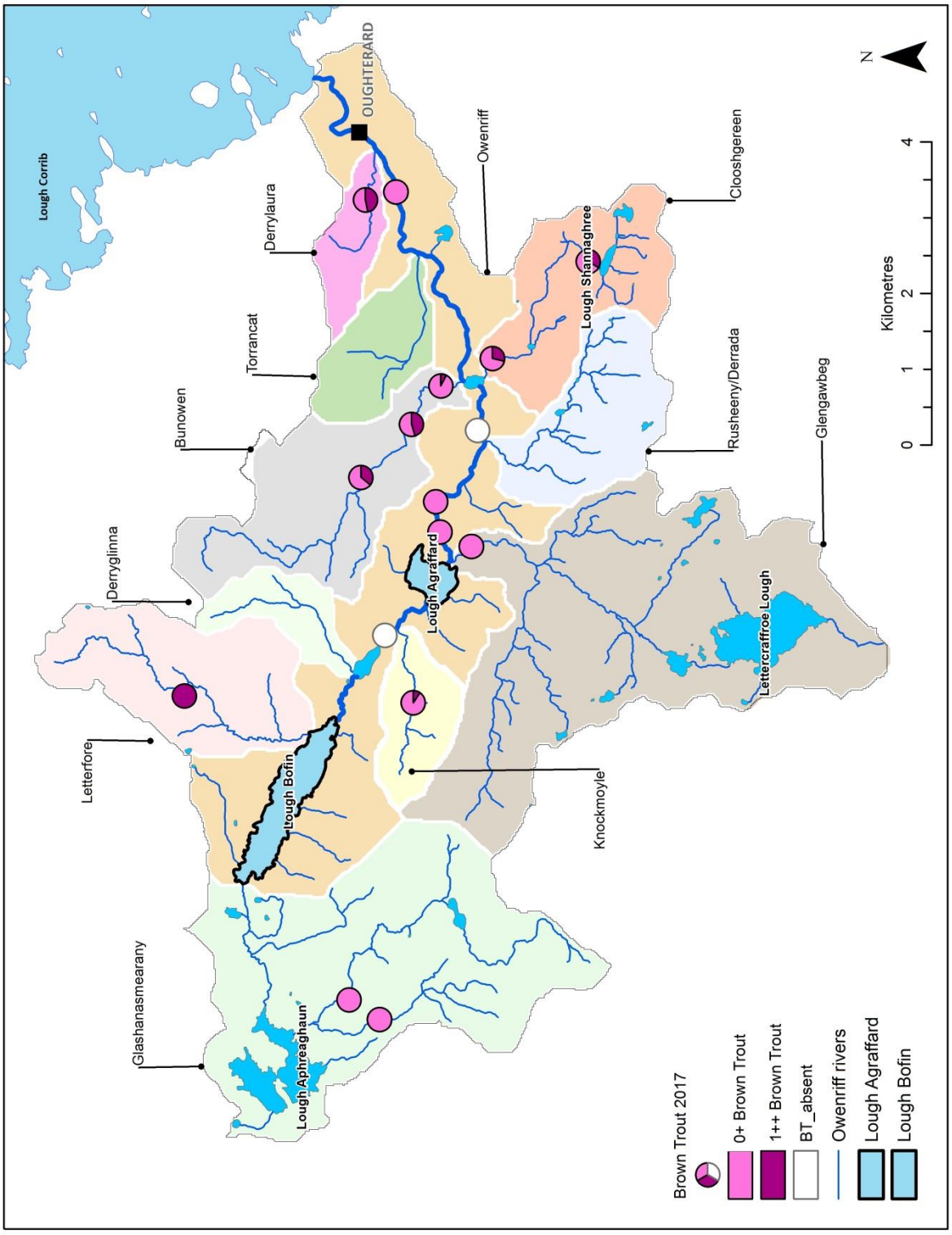


Fig. 4.8. Presence and absence of brown trout at river sites, Owenriff catchment, 2017

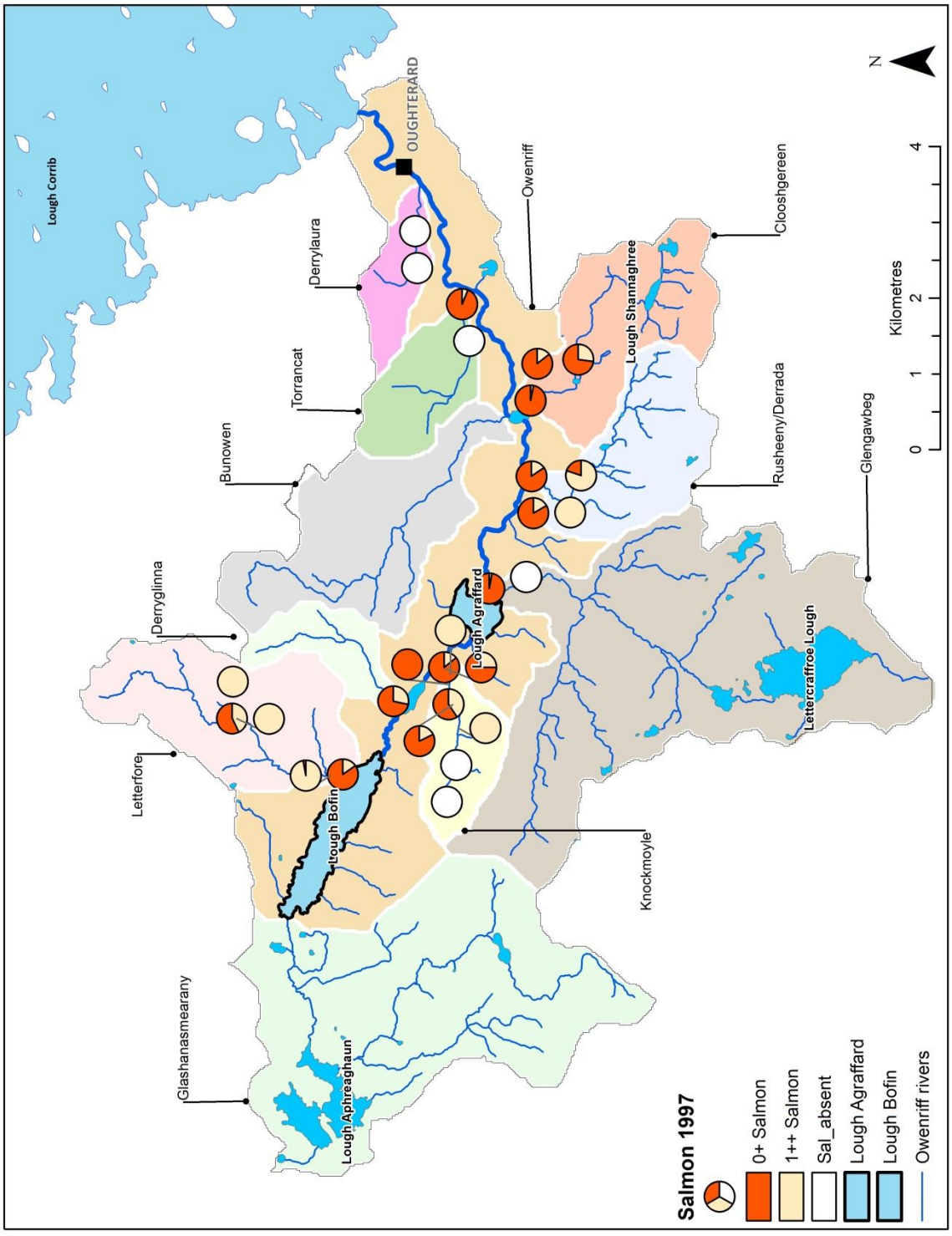


Fig. 4.9. Presence and absence of salmon at river sites, Owenriff catchment, 1997

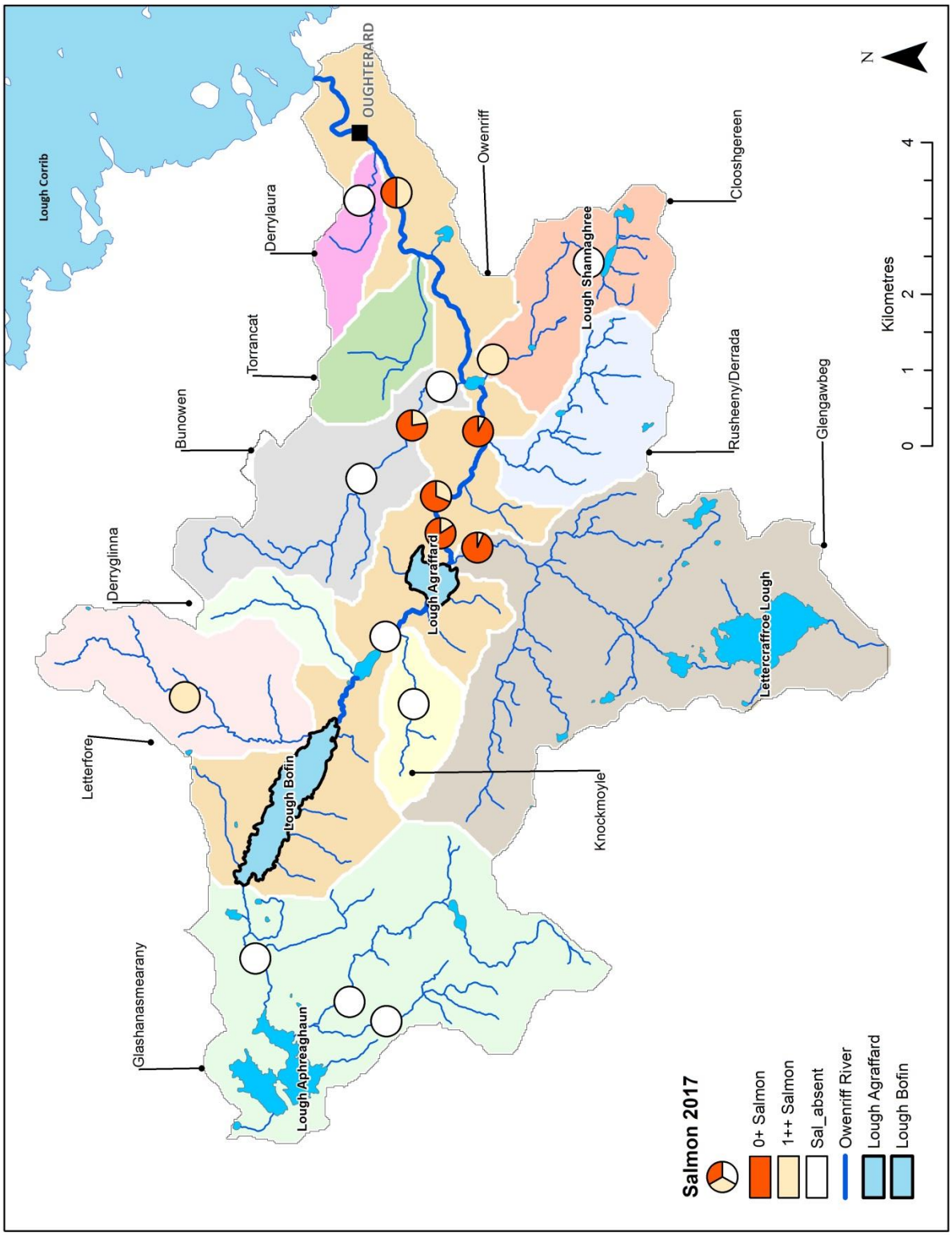


Fig. 4.10. Presence and absence of salmon at river sites, Owenriff catchment, 2017

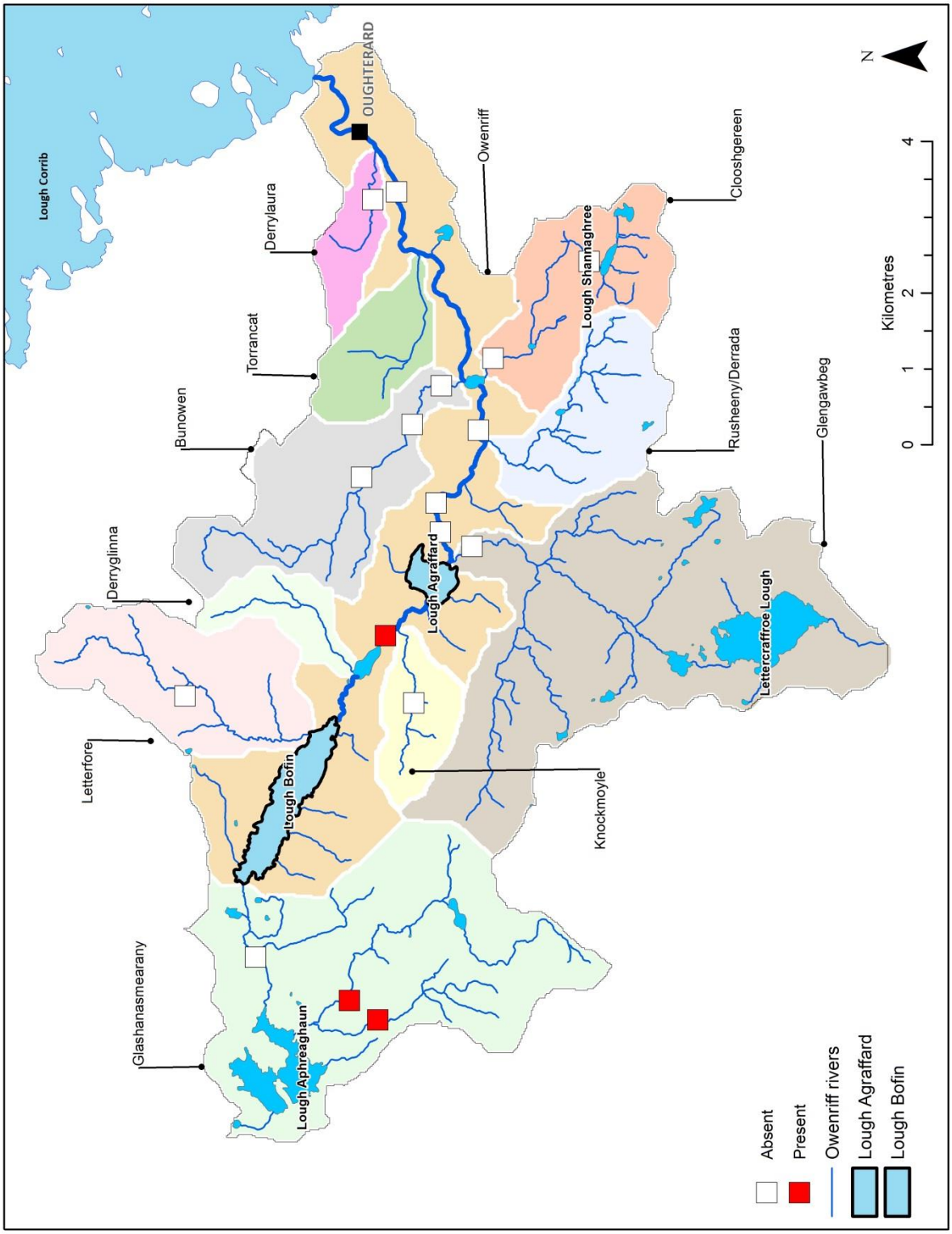


Fig. 4.11. Presence and absence of pike at river sites, Owenriff catchment, 2017

4.1.11 Comparison of 2017 rivers data to 1997 survey and to the Cornamona sub-catchment (a similar sub-catchment in the Corrib catchment)

Catchment wide electrofishing surveys were carried out within the Owenriff catchment in 1997, as part of the Tourism Angling Programme (TAM – IFI unpublished data, 1997) and in 2007 as part of a recommendation by the Owenriff Working Group investigating the role of forestry in relation to the proliferation of filamentous algae in the catchment (WRFB, 2008). In addition the WFD programme has one surveillance monitoring site on the main channel that was surveyed in 2010 and 2015 (Kelly *et al*., 2011 and 2016). While the sampling methods employed during these previous surveys and sampling locations are not fully comparable the information collected does allow for some comparison of the distribution of fish stocks between years.

The survey of 1997 encountered five fish species while the 2007 and 2017 surveys recorded four species (Table 4.13). No samples of three spined stickleback were recorded in any sites surveyed. The most significant difference in species composition is the presence of pike; the species were not captured in the 1997 and 2007 surveys but were recorded in the 2015 and 2017 surveys (Table 4.13).

Table 4.13. Fish species recorded in the Owenriff each survey year

	Survey Year				
Fish Species	**1997 (28 sites all habitats)**	**2007 (33 sites riffles only)**	**2010 (1 site all habitats)**	**2015 (1 site all habitats)**	**2017 (17 sites all habitats)**
Brown trout	√	√	√	√	√
European eel	√	√			
Minnow	√	√	√	√	√
Pike				√	√
Three spined stickleback	√				
Salmon	√	√	√	√	√

Eight tributary sub-catchments were included in the 1997 electrofishing survey while nine sub-catchments and the main channel were surveyed in 2017. There is some evidence that salmon and brown trout numbers in river sub-catchments across the Owenriff catchment have contracted since the previous survey in 1997. In general the proportions of 1+ and older brown trout were lower at many

sites across the catchment in 2017 when compared to the 1997 survey (Figs. 4.7 and 4.8). A comparison of fish density estimates for brown trout and salmon from all sites surveyed in 1997 and 2017 was conducted simply using box plots and suggests that there is some degree of difference between the two survey periods (Fig. 4.12); however there was no statistically significant difference when the overall mean densities were compared (Fig 4.12).

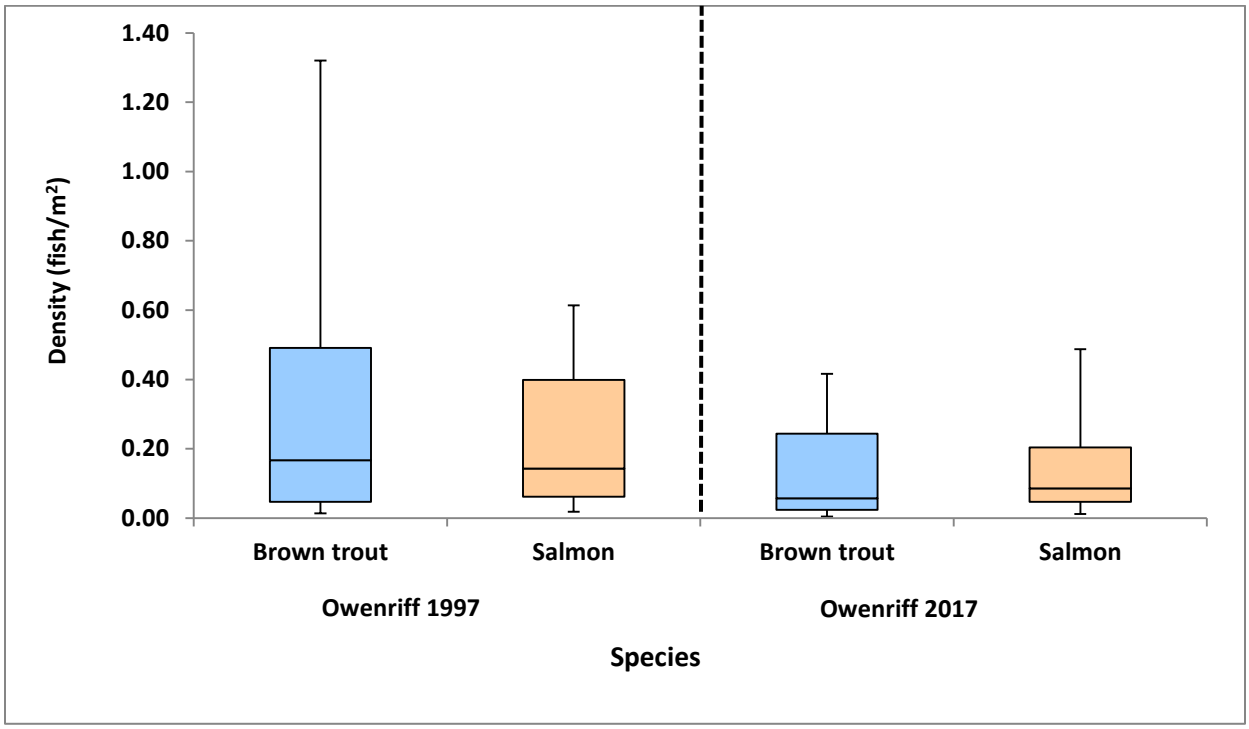


Fig. 4.12. Minimum density estimate box plots for brown trout and salmon (minimum, max and median density estimate values are shown with S.E), all sites surveyed in the Owenriff River 1997 and 2017

Five tributary sub-catchments were surveyed in both 1997 and 2017 which allows for some comparison of the fish data to be made between these survey occasions. Within each of the five sub-catchments there was one individual site that was surveyed in both 1997 and 2017 (Fig. 4.14). Overall there appears to be a general trend for decreasing fish population density estimates from 1997 to 2017 for all life stages both for brown trout and salmon with the exception of brown trout 1+ and older in the Derrylaura tributary (Fig 4.14). Total brown trout density was significantly lower in 2017 than 1997 at the five sites (Wilcoxon test, z=-2.023, P=0.043).

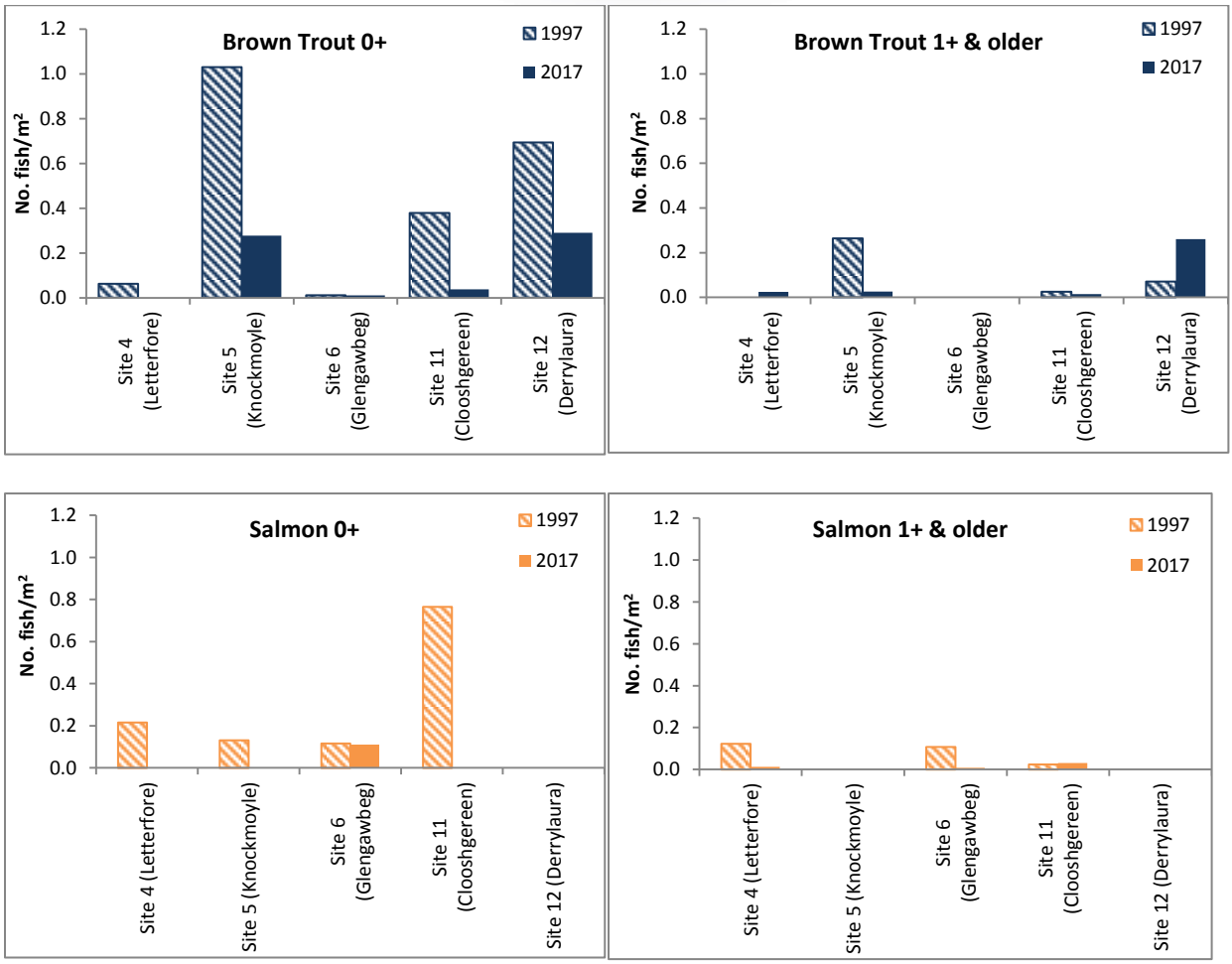


Figure 4.13. Comparison of minimum fish population density estimate for five sites on the Owenriff sub-catchments, 1997 and 2017

The Owenriff is one of many sub-catchments of the Lough Corrib system that were surveyed during 1997 (IFI unpublished data, 1997). The Cornamona sub-catchment, located to the north-west of Lough Corrib, has many similar physical and chemical attributes and would be considered a comparable catchment to the Owenriff sub-catchment. The fish population data for both these systems from 1997 are presented as simple box plots (Fig 4.14). The Cornamona sub-catchment would have been classed as a productive salmonid system in 1997 and Figure 4.15 illustrates that brown trout and salmon density in Owenriff sub-catchments was less productive but not dissimilar to it at that time.

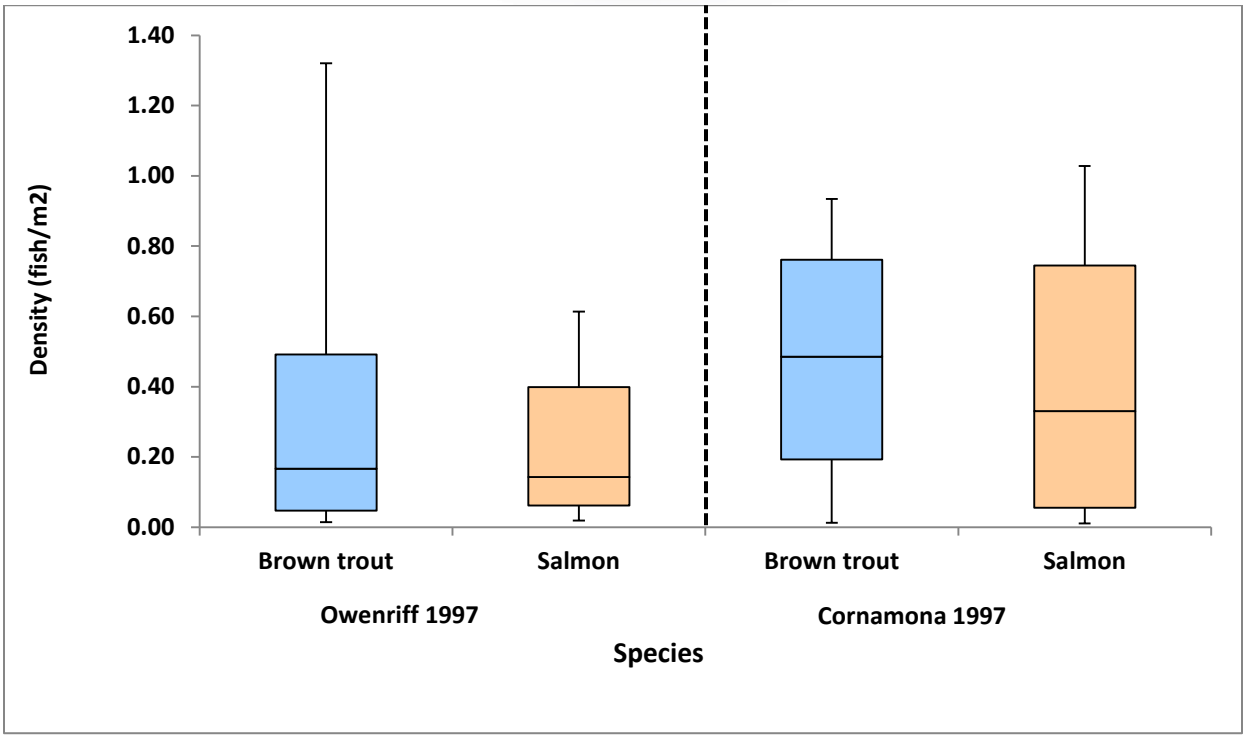


Fig. 4.14. Comparison of minimum density estimates box plots for brown trout and salmon (minimum, maximum and median density estimate values are shown with S.E), all sites surveyed in the Owenriff sub-catchment (1997) and Cornamona sub-catchment (1997)

4.2 Lakes

4.2.1 Species Richness

A total of three fish species were recorded in both Lough Bofin and Lough Agraffard in June 2017, with only 7 and 19 fish being captured respectively (Table 4.14). Eel was the most common fish species recorded in Lough Bofin, followed closely by brown trout and pike, while pike was the most common fish species in Lough Agraffard (Table 4.14).

Table 4.14. Number of each fish species captured by each gear type during the survey on Lough Bofin and Lough Agraffard, June 2017

Lake	Scientific name	Common name	Number of fish captured			
			BM CEN	4-PBB	Fyke	Total
Bofin	*Salmo trutta*	Brown trout	1	1	0	2
	Esox lucius	Pike	1	0	1	2
	Anguilla anguilla	European eel	0	0	3	3
Agraffard	*Salmo trutta*	Brown trout	2	0	0	2
	Esox lucius	Pike	3	0	11	14
	Anguilla anguilla	European eel	0	0	3	3

4.2.2 Fish abundance

Mean CPUE and BPUE for all fish species captured in both lakes during the 2017 surveys are summarised in Table 4.15. Mean CPUE and BPUE for all species is illustrated in Figures 4.15 and 4.16. Pike was the dominant fish species in terms of abundance (CPUE) and biomass (BPUE) captured in the survey gill nets in Lough Agraffard (Table 4.2, Figs. 4.15 and 4.16). The mean CPUE of pike was higher than brown trout in Lough Bofin, and in contrast the mean BPUE of brown trout was higher than that for pike (Table 4.2, Figs. 4.15 and 4.16). In general the abundance of brown trout and pike was lower in Lough Bofin than in Lough Agraffard; however it should be noted that very small numbers of each species were captured during the surveys. Mean CPUE and BPUE of eel was similar in both lakes (Table 4.15).

Table 4.15. Mean (S.E.) CPUE and BPUE for all fish species captured on Lough Bofin, 2017

Lake	Scientific name	Common name	Mean CPUE 2017	Mean BPUE 2017
Bofin	*Salmo trutta*	Brown trout	0.002 (0.002)	0.449 (0.373)
	Esox lucius	Pike	0.003 (0.002)	0.187 (0.144)
	Anguilla anguilla	European eel	0.017 (0.017)	9.558 (9.558)
Agraffard	*Salmo trutta*	Brown trout	0.004 (0.003)	0.361 (0.282)
	Esox lucius	Pike	0.019 (0.007)	1.702 (0.832)
	*Anguilla anguilla**	European eel*	0.017 (0.010)	9.520 (5.146)

Note: On the rare occasion where biomass data was unavailable for an individual fish, this was determined from a length/weight regression for that species (Connor *et al*., 2017). *Eel CPUE and BPUE based on fyke nets only

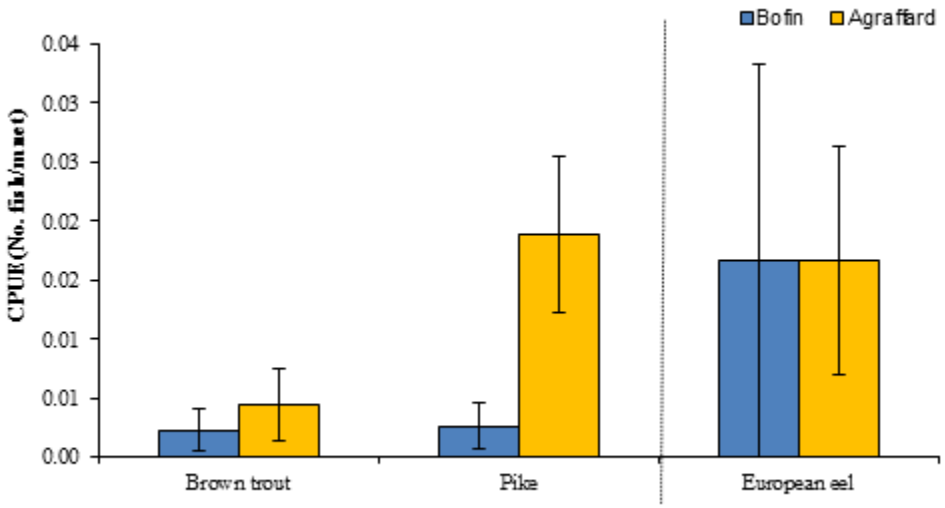


Fig. 4.15. Mean (±S.E.) CPUE for all fish species captured in Lough Bofin and Lough Agraffard (Eel CPUE based on fyke nets only), 2017

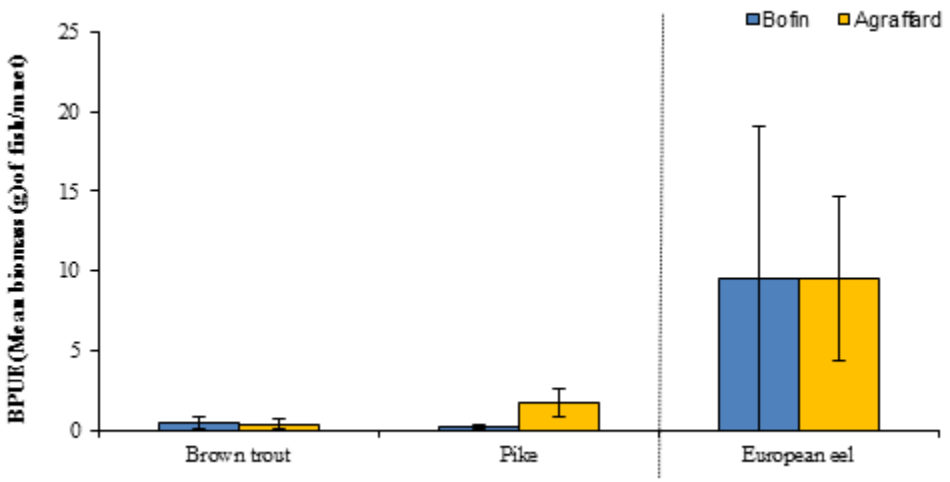


Fig. 4.16. Mean (±S.E.) BPUE for all fish species captured in Lough Bofin and Lough Agraffard (Eel BPUE based on fyke nets only), 2017

The relative abundance of brown trout captured in Loughs Agraffard and Bofin was compared to Lettercraffroe Lough, also located in the Owenriff sub-catchment (no pike are present in the lake) and to other similar low alkalinity lakes surveyed by IFI (Fig. 4.17). There were significant differences recorded in the relative abundance of trout captured (Kruskal-Wallis rank sum test: $X^2 = 98.643$, df =8, $P < 2.2^{-16}$). The mean CPUEs of brown trout in Loughs Agraffard and Bofin respectively were significantly lower than all of the similar lakes with data available which don't contain pike (Wilcoxon pairwise rank sum test: Doo, p = 0.00271 & 0.00054; Glencullin, p = 0. 00037 & 5.0^{-05}; Kylemore, p = 0.00098 & 0.00017; Lettercraffroe, p = 0.00037 & 6.9^{-05}) (Fig. 4.17).

The relative abundance of pike captured in Loughs Agraffard and Bofin compared to other low alkalinity lakes containing pike is presented in Figure 4.18. There were no significant differences recorded (Kruskal-Wallis rank sum test: $X^2 = 7.3528$, df = 4, p = 0.1184), although the mean CPUE for Lough Agraffard was higher than the other lakes surveyed (Fig. 4.18).

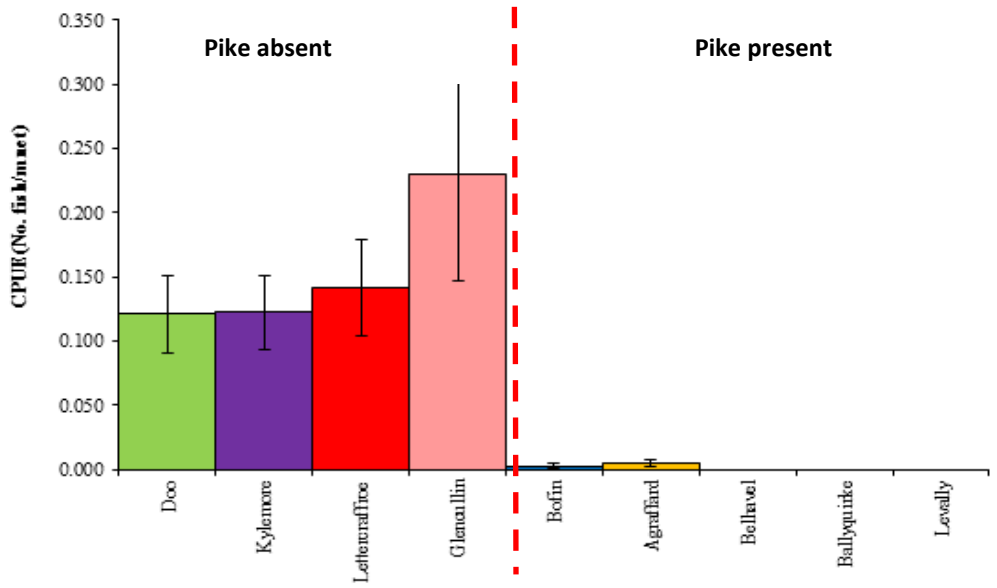


Fig. 4.17. Comparison of mean (±S.E.) CPUE for brown trout captured in Loughs Bofin and Agraffard with other lakes of similar alkalinity (no pike are present in Loughs Doo, Kylemore, Lettercraffroe (Owenriff sub-catchment) and Glencullin)

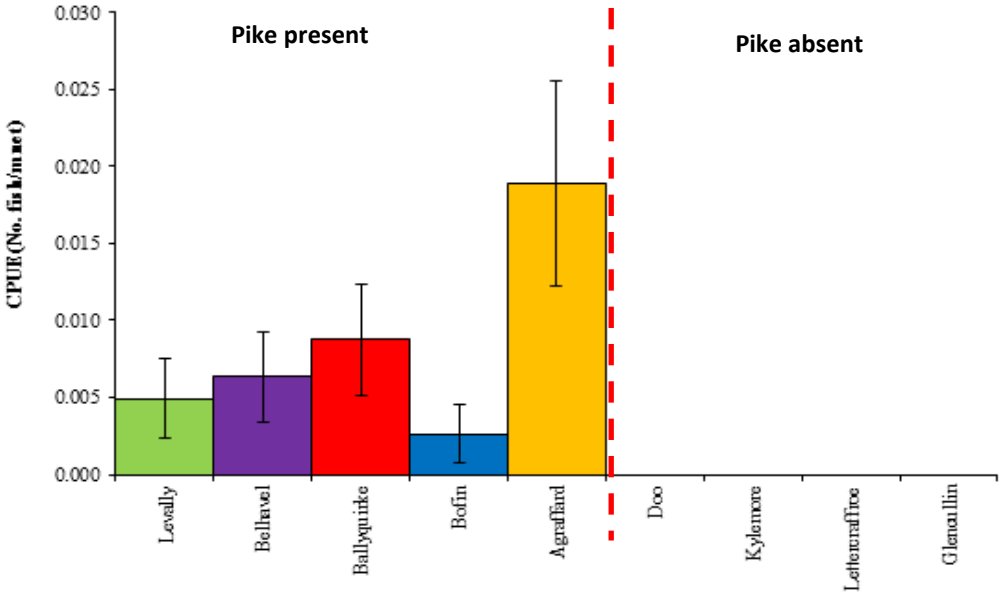


Fig. 4.18. Comparison of mean (±S.E.) CPUE for pike captured in Loughs Bofin and Agraffard to other lakes of similar alkalinity

4.2.3 Length frequency distributions and growth

Brown trout

Only two brown trout were captured during the 2017 survey on Lough Bofin and these measured 24.5cm and 25.9cm in length (Fig. 4.19). One age class was present at 2+ with a mean L1 of 8.3cm (Table 4.16). The two brown trout captured during the 2017 survey on Lough Agraffard measured 14.8cm to 21.8cm in length (Fig. 4.19). One age class was present at 2+, with a mean L1 of 6.6cm (Table 4.16).

In contrast the brown trout captured during the 2016 survey on Lettercraffroe Lough ranged in length from 7.2cm to 30.5cm (mean = 19.2cm) (Fig. 4.19). Five age classes were present, ranging from 0+ to 4+, with a mean L1 of 7.0cm (Table 1.4). The dominant age class was 3+ (Fig. 4.19). Mean brown trout L4 in 2016 was 27.2cm indicating a slow rate of growth for brown trout in this lake according to the classification scheme of Kennedy and Fitzmaurice (1971). Brown trout captured during the 2010 and 2013 surveys on Lettercraffroe Lough had similar length and age ranges (Kelly *et al*., 2011 and 2014).

Table 4.16. Mean (±S.E.) brown trout length (cm) at age for Lough Bofin and Agraffard, 2017

Lake		L_1	L_2
Bofin	Mean (±S.E.)	8.3 (0.7)	20.5 (0.02)
	N	2	2
	Range	7.6-9.0	20.5-20.5
Agraffard	Mean (±S.E.)	6.6 (0.8)	14.7 (3.6)
	N	2	2
	Range	5.7-7.4	11.1-18.3

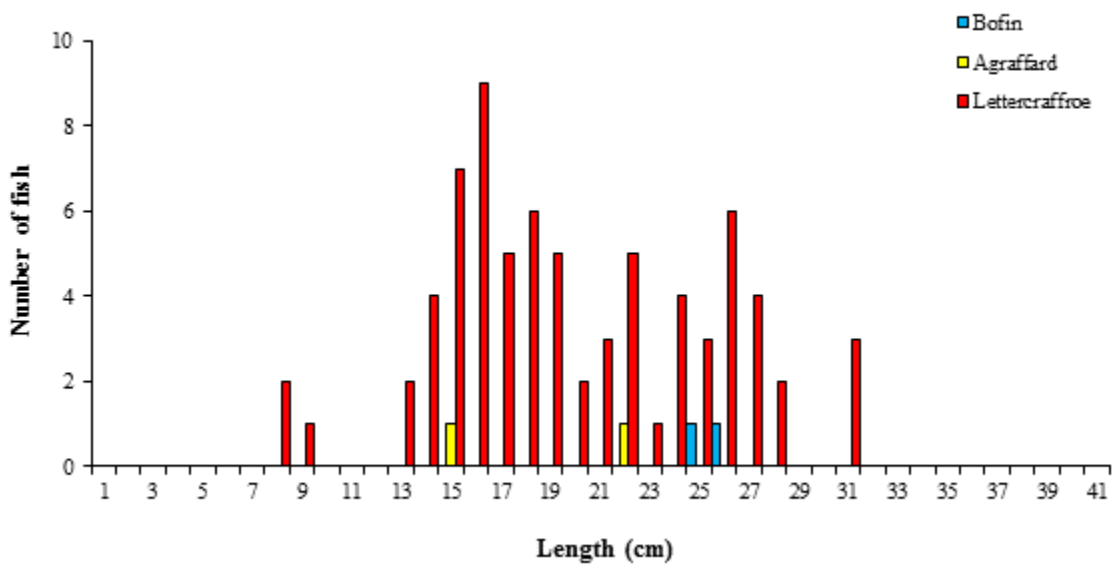


Fig. 4.19. Comparison of the length frequency of brown trout captured in three lakes in the Owenriff catchment, 2016 (Lettercraffroe lake) and 2017 (Loughs Bofin and Agraffard)

Pike

Two pike were captured during the 2017 survey on Lough Bofin measuring 19.5cm and 23.3cm in length (Fig. 4.20). One age class was present at 1+, with a mean L1 of 13.3cm. Fourteen pike were captured during the 2017 survey on Lough Agraffard and ranged in length from 8.5cm to 36.2cm (mean = 19.9cm) (Fig. 4.20). Three age classes were present ranging from 0+ to 3+, with a mean L1 of 12.1cm. This is similar to Belhavel Lough, a low alkalinity lake located in Co. Leitrim (Garavogue catchment) where pike exhibited a mean L1 of 12.4cm with ages ranging from 4+ to 6+, whilst in Ballyquirke Lough (Corrib catchment) and Levally Lough (Moy catchment) pike ranged in age from 0+ to 6+ and 3+ to 6+ respectively, with a mean L1 of 17.7cm and 17.8cm (Kelly *et al*., 2017).

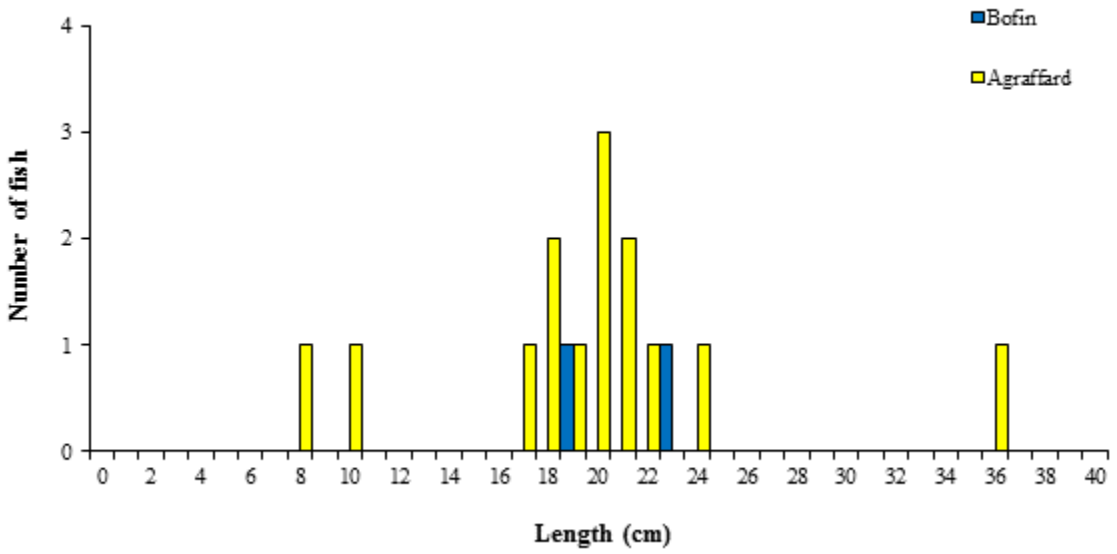


Fig. 4.20. Length frequency of pike captured on Lough Bofin and Lough Agraffard, 2017

Other fish species

Eels captured during the 2017 survey on Lough Bofin ranged in length from 61.5cm to 72.0cm and ranged in length from 61.3cm to 72.5cm on Lough Agraffard.

4.2.4 Stomach and diet analysis

Dietary analysis studies provide a good indication of the availability of food items and the angling methods that are likely to be successful. However, the value of stomach content analysis is limited unless undertaken over a long period as diet may change on a daily basis depending on the availability of food items. The stomach contents of a subsample of brown trout and pike captured during the surveys on Loughs Agraffard and Bofin were examined and are presented below.

Brown trout

Adult trout usually feed principally on crustaceans (*Asellus* sp. and *Gammarus* sp.), insects (principally chironomid larvae and pupae) and molluscs (snails) (Kennedy and Fitzmaurice, 1971, O'Grady, 1981). Two stomachs were examined from Lough Bofin and both contained 100% invertebrates. The two samples from Lough Agraffard were also examined; of these one was empty and the remaining one contained 100% invertebrates.

Pike

A total of ten pike stomachs were available for analysis of diet. Of these fish nine (seven from Lough Agraffard and two from Lough Bofin) contained prey. Pike in the sample ranged in length from 17.8cm to 36.2 cm.

In Lough Bofin, stomachs of both pike (19.5cm and 23.3cm) contained invertebrates only. Invertebrates were found in the stomachs of five pike (20.6cm to 36.2 cm) in Lough Agraffard (Table 4.17). In addition fish were found in the stomachs of three pike (17.8cm to 36.2cm) in Lough Agraffard (Table 4.17). The larger pike also had invertebrates in their stomach. All of the fish recorded in stomachs were identified as young of the year (YOY) pike, with an estimated length of between *c*.3.7cm and *c*. 7.5 cm.

More detailed analysis revealed that four prey types were recorded in the stomachs analysed (Table 4. 17). These were freshwater shrimp (Gammaridae), pike, damsel fly (Odonata) (adults & larvae combined) and midge (Diptera) (adults & larvae combined). The percentage relative importance (%IRI) of these items to the diet of the sampled pike is presented in Figure 4.21. Freshwater shrimp were recorded in three (33.3%) of the nine stomachs which contained food. Seventy-four individual shrimp were recorded in one pike (20.6 cm in length). A total of 104 individual prey items were recorded, representing *c*. 82% and *c* 16% of prey numbers and biomass respectively. All pike found to have

consumed freshwater shrimp were captured in Lough Agraffard. The IRI was 48.92%, representing the most important food item in the sampled pike (Table 4.17 & Figure 4.21).

Pike were recorded in three (33.3%) of the nine stomachs which contained food. A total of three individual prey items were recorded, representing *c.* 2.4% and *c*. 73% of prey numbers and biomass respectively. All pike found to have consumed YOY pike were captured in Lough Agraffard. The IRI was 37.83%, representing the second most important food item in the sampled pike. In addition four individual freshwater shrimp were also observed in the stomach of one of the predated YOY pike (3) (Table 4.17 & Figure 4.21 & Plate 13).

Damsel fly were recorded in three (33.3%) of the nine stomachs which contained food and were recorded in pike from both lakes. A total of 16 individual prey items were recorded, representing *c*. 1.8% and 12.6% of prey numbers and biomass respectively and the IRI was 11.34% (Table 4.17 & Figure 4.21).

Specimens of midge were recorded in three (33.3%) of the nine stomachs which contained food. While midge specimens were recorded in the stomachs of pike from both lakes, they were a relatively unimportant component of the diet of the sampled pike. A total of four midge were recorded, representing *c.* 3% and < 2% of prey numbers and biomass respectively and the combined IRI was 1.92% (Table 4.17 & Figure 4.21).

Table 4.17. Summary dietary analysis of 10 pike captured during a survey of Loughs Agraffard and Bofin, conducted in June 2017

			L. Agraffard	L. Bofin	L. Agraffard & Bofin
Pike		N Pike	8	2	10
		N (Stomachs with food)	7	2	9
		Total Prey Biomass	4.77	0.27	5.04
		Total Prey Numbers	111.00	16.00	127.00
Prey Item	Midge	Biomass (g)	0.02	0.02	0.04
		% Biomass	0.36	6.59	0.69
		Numbers	2.00	2.00	4.00
		% Numbers	1.80	12.50	3.15
		%O	25.00	50.00	33.33
		IRI	53.95	954.67	128.12
		%IRI	0.64	9.55	1.92
	Damsel Fly	Biomass (g)	0.25	0.26	0.51
		% Biomass	5.30	93.41	10.07
		Numbers	2.00	14.00	16.00
		% Numbers	1.80	87.50	12.60
		%O	28.57	50.00	33.33
		IRI	203.02	9045.33	755.73
		%IRI	2.41	90.45	11.34
	Shrimp	Biomass (g)	0.80	-	0.80
		% Biomass	16.86	-	15.94
		Numbers	104.00	-	104.00
		% Numbers	93.69	-	81.89
		%O	42.86	-	33.33
		IRI	4737.82	-	3261.09
		%IRI	56.19	-	48.92
	Pike	Biomass (g)	3.70	-	3.70
		% Biomass	77.48	-	73.29
		Numbers	3.00	-	3.00
		% Numbers	2.70	-	2.36
		% O	42.86	-	33.33
		IRI	3436.58	-	2521.73
		%IRI	40.76	-	37.83

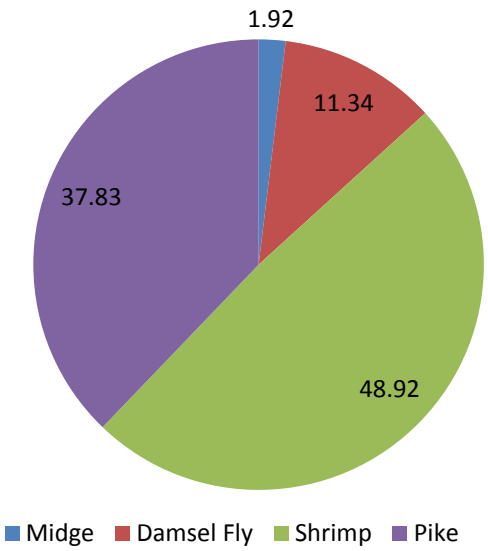


Fig. 4.21. Relative importance (expressed as the % IRI) of four prey items recorded in the stomachs of pike in Loughs Agraffard and Bofin in June 2017

Plate 13. Stomach contents (highlighted) of a pike (length =17.9cm) captured in Lough Agraffard in June 2017. The smaller pike (prey item) was found to have consumed 4 small shrimp (highlighted in red)

4.3 Ecological status

Using the FCS2-Ireland tool and expert opinion, each Owenriff river site surveyed in 2017 was assigned a fish ecological status (Fig. 4.22). Four river sites achieved Good fish status; however the remaining 13 sites were assigned moderate or lower fish status (nine Moderate fish status, two sites Poor status and two sites Bad fish status) (Fig. 4.22). These failures were mainly due to the absence, lower than expected abundance or missing age classes of type specific indicator species (brown trout and salmon).

One site on the main channel (Site 15) is a designated surveillance monitoring site for fish and was assigned a fish ecological status of Good in 2010 and 2015; however in 2017 it was assigned a fish ecological status of Moderate (Fig. 4.22) due to lower than expected abundance of type specific indicator species and missing age classes of these species. In contrast the EPA assigned good and high status to their monitoring sites for the 2010 to 2015 period; however fish status were only included in one of these sites (Appendix 2; EPA, 2017).

Using the FIL2 classification tool, Lough Bofin and Lough Agraffard were assigned a fish ecological status of Poor and Bad respectively for 2017 based on the fish populations present. In contrast the EPA assigned Lough Bofin an overall ecological status of High for the 2010 to 2015 surveillance monitoring reporting period; however the status of the fish populations was not included in this classification. Reasons for the failures were mainly due to the absence, lower than expected abundance or missing age classes of type specific indicator species (i.e. brown trout). In comparison, Lettercraffroe Lough (also Owenriff catchment but no pike are present in the lake) was assigned a fish ecological status of Good in 2016. Also lakes in neighbouring catchments where there are no pike present, such as Glencullin Lough, Doo Lough, Kylemore Lough and Lough Shindilla, were assigned a fish status of High and Ardderry Lough was assigned a fish status of Good.

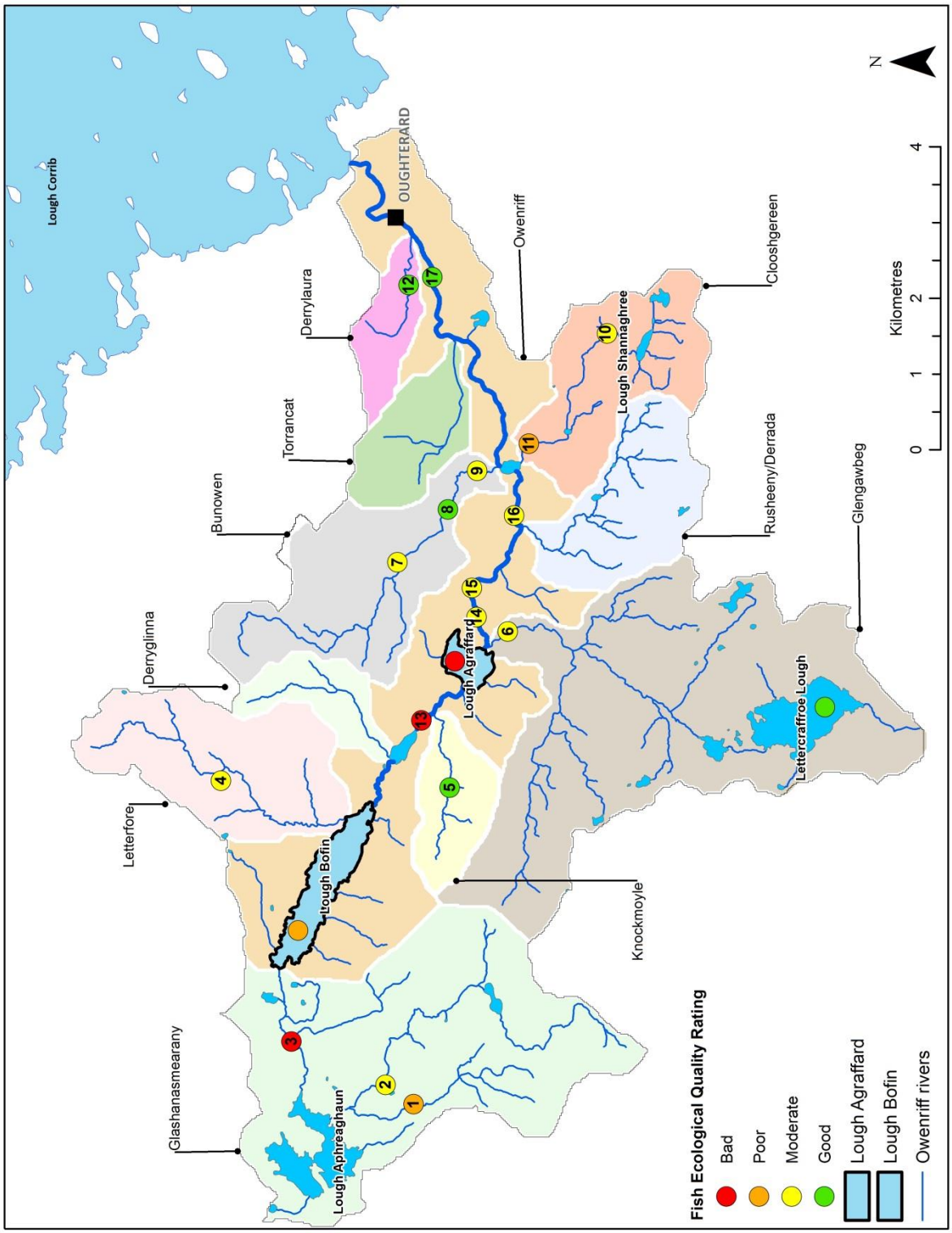


Figure 4.22. Fish ecological status classification at selected lake and river sites, Owenriff catchment 2017

5. Discussion/Conclusions

Brown trout and salmon were the two most frequently encountered and abundant fish species recorded across the 17 river sites surveyed in the Owenriff catchment during 2017. In total four fish species were recorded in the rivers survey. Brown trout were recorded at 14 individual sites within nine river sub-catchments and were absent from the remaining three sites. Density estimates for 0+ brown trout were relatively poor at many sites. Salmon were present at only eight sites across five river sub-catchments and density estimate values were also relatively poor for this species. Overall 0+ brown trout and salmon were more dominant than 1+ and older fish. Brown trout density estimates were highest on the Derrylaura, one site on the Bunowen and Knockmoyle tributaries for both 0+ and 1+ fish, while salmon density estimates were highest in the Bunowen, Owenriff main channel and Glengawbeg for 0+. It should be noted that in general the 2017 minimum density estimates for both trout and salmon were relatively low.

There is some evidence that salmon and brown trout numbers in river sub-catchments across the Owenriff catchment have declined since the previous survey in 1997. In general the proportions of 1+ and older brown trout were lower at many sites across the catchment in 2017 when compared to the 1997 survey. Data collected shows that the density of the majority of comparable life stages for both trout and salmon were lower in 2017 than those recorded for 1997 with the exception of 1+ and older brown trout at one site in the Derrylaura sub-catchment. Total brown trout density was significantly lower in 2017 than 1997 at five matched sites. In general salmon were more prevalent across the catchment in 1997. While this was also the case for 2017 it was far less obvious with little difference noted in the total numbers of trout and salmon recorded.

Three fish species were recorded in both Loughs Bofin and Agraffard in June 2017. Pike were the most common fish species captured in the survey gill nets in Agraffard Lough while equal numbers of brown trout and pike were captured in Lough Bofin. However the mean biomass (BPUE) of brown trout was higher than pike in this lake. Pike and eel were also captured in the fyke nets in both lakes. Only one age class of brown trout (2+) was recorded in both lakes indicating a possible failure in recruitment in at least the previous two years. In contrast the brown trout captured in Lettercraffroe Lough (also located in the Owenriff catchment but no pike are present in the lake) during the 2016 ranged in age from 0+ to 4+ indicating recruitment success in the previous five years.

Definitive conclusions are difficult to determine for both lakes surveyed due to the limited number of fish recorded, in particular for Lough Bofin; however brown trout abundances were poor and significantly lower in comparison to other lakes within the Owenriff (Lettercraffroe) and in neighbouring catchments (Loughs Doo, Glencullin, Kylemore and Lettercraffroe) where pike are not present.

Using the River fish classification tool (FCS2) and expert opinion four river sites were assigned Good fish status; however the remaining 13 sites were assigned Moderate or lower fish status (nine Moderate fish status, two sites Poor status and two sites Bad fish status). These failures were mainly due to the absence, lower than expected abundance or missing age classes of type specific indicator species (brown trout and salmon). One site on the main channel (Site 15) is a designated surveillance monitoring site for fish and its ecological fish status has deteriorated from Good in 2010 and 2015 to Moderate in 2017; it was assigned a fish ecological status of Moderate due to lower than expected abundance of type specific indicator species and missing age classes of these species. The most recent EPA WFD assessment of the catchment (2010 to 2015) has assigned the entire Owenriff main channel and most of its sub-catchments as Good ecological status, apart from the Glengawbeg sub-catchment which was assigned High status indicating that there are little or no water quality or other anthropogenic pressures in the catchment; however fish status from only one site was included in this assignment.

Using the FIL2 classification tool, Loughs Bofin and Agraffard were assigned a fish ecological status of Poor and Bad respectively for 2017 based on the fish populations present. In contrast Lettercraffroe Lough was assigned a status of Good in 2016. Reasons for the failures were mainly due to the absence, lower than expected abundance or missing age classes of type specific indicator species (i.e. brown trout). The EPA assigned Lough Bofin an overall ecological status of High for the 2010 to 2015 surveillance monitoring reporting period indicating that there are little or no water quality pressures on the lake; however the status of the fish population was not included in this classification.

Pike were confirmed present for the first time in two lakes in the Owenriff catchment in 2009 by IFI WRBD staff. They weren't recorded during the 1997 and 2007 catchment wide river electrofishing surveys (IFI unpublished data; WRBD, 2007) and the surveys of Lettercraffroe lake in 2010, 2013 and 2016 (Kelly *et al*., 2011, 2014 and 2017). Pike were recorded in a quantitative river electrofishing survey at the designated WFD fish surveillance monitoring site for the first time in 2015 (site 15 – 1km downstream of Agraffard lake). During the 2017 survey pike were recorded at three river sites including

the most upstream sub-catchment and in the two lakes surveyed, indicating a range expansion over the past 20 years. Results indicate that they are present all over the Owenriff catchment, in areas where they can gain access and in some areas where they cannot naturally gain access (gradients >7%) (Appendix 4 and 5). The relative abundance of pike captured in Loughs Agraffard and Bofin was similar when compared to other low alkalinity lakes in Co. Galway, Leitrim and Mayo, containing pike (no significant difference).

Invertebrates dominated prey items in the pike stomachs examined in both lakes, with the three invertebrate prey types (shrimp, damsel fly and midge) combined accounting for in excess of 70% IRI (Index of Relative importance) for pike in both lakes. Invertivory is not uncommon in pike of this size, particularly in an Irish context, where invertebrates are an important dietary component for smaller pike (Pedreschi *et al*., 2014; Healy, 1956). Pike are also known to feed on invertebrates in the absence of alternative fish prey (Venturelli and Tonn, 2006) or when fish prey populations have become reduced (Haught and Von Hippel, 2011). On a national scale, it has been suggested that this emphasis on invertebrates may be related to the depauperate nature, at least historically, of Ireland's fish fauna compared to those elsewhere where pike occur (Pedreschi *et al*., 2014). In the lakes surveyed, YOY pike were found to be the only fish prey found in the pike stomachs examined. A single pike was found in three stomachs, representing *c*. 38%IRI. This is perhaps unsurprising in the context of the small numbers of the other fish species recorded. Furthermore, such intra-specific predation is an important factor regulating survival of juvenile pike cohorts (Grimm and Klinge, 1996). No brown trout were recorded in the pike stomachs during the surveys of both lakes in the Owenriff during the 2017 surveys. However, as pike are gape limited predators (Nilsson and Brönmark, 2000), it is probable that trout migrating to the lakes from connected streams as one year old fish (at *c*. 8 to 10cm) would be unavailable to many of the largely one year old pike which dominated the sample. Brown trout of this size are likely to be available only to the largest pike (36.2cm) recorded in the sample. It should be noted, however, that larger pike are present within lakes in the catchment, with pike to in excess of 75cm caught by anglers in November 2017. Indeed, caution must be used when interpreting the data presented here as it provides just an insight into the diet at the time that the survey was conducted and is limited by both the size of the sample and also by the relatively small size range of the fish captured in the nets.

Pike are an apex (opportunistic, but predominantly piscivorous) predator (Craig, 2008) and can shape fish communities in waters where they occur (DeBates *et al*., 2003). These impacts may be directly

through predation (e.g. Sepulveda *et al*., 2013), and competition and predation (Byström *et al*., 2007). Indirect impacts, through predation mediated changes in behaviour (He *et al*., 1990) and life history strategy (Heins *et al*., 2016) have also been demonstrated. The ability of pike to reduce or even extirpate resident fish species have been described across Europe (e.g. Hesthagen *et al*., 2015) and North America (Nicholson *et al*., 2015; Sepulveda *et al*., 2013, Patankar *et al.,* 2006) where pike have expanded beyond their historical range. Such changes in fish community structure are a common feature in areas where pike are recent colonisers (Craig, 1996). The potential of salmonids to coexist with pike has been examined by a number of authors (e.g. Hein *et al*., 2014, Spens and Ball, 2008; Bystrom *et al*., 2008). No coexistence was recorded in a total of 1028 boreal lakes in Sweden, where pike and salmonids were found to be mutually exclusive (Spens and Ball, 2008). Elsewhere, however, abiotic factors including lake area and air temperature were found to be important variables predicting a potential coexistence niche for pike and brown trout (Hein *et al*., 2014). The importance of habitat morphology in determining resistance to predation by pike has been described for a number of fish species in North America, including stickleback (*Gasterosteus aculeatus*) (Haught and Von Hippel, 2011) and salmonids (Sepulveda *et al*., 2013). Indeed, the degree of connectivity to pike (i.e. the ability of pike to enter a waterbody naturally) is believed to be a primary factor influencing the distribution of fish communities in boreal lakes in Sweden (Hein *et al*., 2011, Spens *et al*., 2007). In both studies, stream slopes in excess of 6.6% (Spens *et al.,* 2007) and 7% (Hein *et al*., 2011) were shown to act as barriers to the natural dispersal of pike. In each instance, lakes isolated from pike were dominated by salmonids (as observed in Lettercraffroe Lough within the Owenriff catchment), whilst fish stocks connected to pike lakes were characterised by species such as perch and roach. In Ireland, historical reports of negative impacts on trout populations have been described in a number of previously isolated lakes and rivers (Went, 1957). In Lough Ross (Corrib catchment), for example, connectivity to a population of resident pike in Lough Corrib was created following the construction of a canal in the mid-1800s and resulted in a reported decline in brown trout stocks at that time (Went, 1957). This lake now supports a coarse fishery and stocks are dominated by cyprinids (Kelly *et al*., 2017).

Brown trout exhibit a high degree of ecological variability and can utilise a wide variety of habitats within complex ecosystems (Klemetsen *et al*., 2003). This adaptability may confer a degree of resistance to predation in the Owenriff catchment with its network of lakes and rivers. In the Owenriff, it is likely that there are populations of trout migrating to lakes and streams within the catchment itself, as well as

fish migrating to Lough Corrib. In Norway, trout were found to persist in streams flowing into a lake where they had apparently been extirpated following the introduction of pike (Hesthagen *et al*., 2014). These authors suggested that while declines in the stream were likely to continue, that the persistence of trout may have been mediated by changes in habitat use and behaviour of trout in the streams after the introduction of pike (Vehanen and Hamari, 2004; Greenberg *et al*., 1997). Conversely, downstream migration during smoltification - or feeding migrations into lakes in the case of brown trout in the Owenriff - is a period where migrating fish are susceptible to enhanced predation risk (Kekäläinen *et al*., 2008; Jepsen *et al*., 2000). Further investigation is required in the Owenriff to determine the mechanisms behind the decline of salmonids in the system following the introduction of pike and identify, and better understand any potential behavioural or habitat factors which might mitigate or reduce these impacts.

As there are little or no major anthropogenic pressures in the catchment to cause the decline in fish stocks, it is reasonable to infer that the introduction of pike is the main factor causing the decline of brown trout and salmon in the Owenriff catchment.

6. Recommendations for ongoing work

- It is recommended that the 2007 catchment wide survey for salmon be repeated in 2018 to put in context the level of salmon escapement, spawning and distribution throughout the catchment.
- It is also recommended that a more detailed quantitative baseline electrofishing fish stock survey be undertaken in 2018 across the catchment with an emphasis on repeating many of the 1997 sites and targeting sub-catchments where there is a paucity of data to investigate further the distribution and abundance of all relevant fish species and the reasons for the decline in brown trout and salmon.
- Three to four lakes should be targeted to assess the status of their fish stocks in 2018, i.e. Loughaphreagaun, Lough Ateeann (Leadmine), Loch an Droichid and Lough Shanagree.
- It is proposed to conduct an in depth acoustic telemetry programme on the Owenriff catchment. This will investigate the behaviour and habitat use of both pike and salmonids within the catchment and also the interactions between them. In this way it is hoped to identify bottlenecks within the catchment.
- A seasonal diet study of pike in the catchment should be undertaken to provide a greater understanding of the diet of pike in the system.
- Habitat mapping of pike spawning areas is also recommended.

7. References

Amundsen P.A., Gabler, H.M., Staldvik, F.J. (1996) A new approach to graphical analysis of feeding strategy from stomach contents data—modification of the Costello (1990) method. *Journal of Fish Biology*, **48**, 607–614.

Browne, J. and Gallagher, P. (1980) *Preliminary Investigation of the Population of Juvenile Salmonids in the Corrib System*. Department of Fisheries and Forestry, Trade and Information Section Dublin 2. Fishery Leaflet Number 103.

Browne, J. and Gallagher, P. (1981) *Population estimates of juvenile salmonids in the Corrib system 1980*. Department of Fisheries and Forestry. Fishery Leaflet Number 112.

Browne, J. and Gallagher, P. (1982) *Population estimates of juvenile salmonids in the Corrib system 1981*. Department of Fisheries and Forestry. Fishery Leaflet Number 115.

Byström, P., Karlsson, J.A.N., Nilsson, P.E.R., Van Kooten, T., Ask, J. and Olofsson, F. (2007) Substitution of top predators: effects of pike invasion in a subarctic lake. *Freshwater biology*, **52(7)**, 1271-1280.

Caffrey, J. (2010) *IFI Biosecurity Protocol for Field Survey Work*. Inland Fisheries Ireland.

Connor, L., Matson R. and Kelly F.L. (2017) Length-weight relationships for common freshwater fish species in Irish lakes and rivers. *Biology and Environment: Proceedings of the Royal Irish Academy*, **117 (2)**, 65-75.

CEN (2003) Water Quality — Sampling of Fish with Electricity. European Standard. Ref. No. EN 14011:2000.

CEN (2005) Water Quality - Guidance on the scope and selection of fish sampling methods. CEN EN 14962

CORINE (2012) CORINE Landcover 2012 Ireland. Final Report.

Cortés, E. (1997) A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. *Canadian Journal of Fisheries and Aquatic Sciences*, **54 (3)**, 726-738.

Craig J.F. (1996) Population dynamics, predation and role in the community. In: Craig J.F. (eds) *Pike*. Fish and Fisheries Series, vol 19. Springer, Dordrecht

Craig, J. F. (2008) A short review of pike ecology. *Hydrobiologia*, **601 (1)**, 5-16.

DeBates, T.J., Paukert, C.P. and Willis, D.W. (2003) Fish community responses to the establishment of a piscivore, northern pike (*Esox lucius*), in a Nebraska Sandhill lake. *Journal of Freshwater Ecology*, **18(3)**, pp.353-359.

EC (2013) Commission Decision of 20 September 2013 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC. Official Journal of the European Union L266/1.

EPA (2017) WFD Status Assessment 2010 to 2015. https://gis.epa.ie/EPAMaps/

Greenberg, L.A., Bergman, E. and Eklöv, A.G. (1997) Effects of predation and intraspecific interactions on habitat use and foraging by brown trout in artificial streams. *Ecology of Freshwater Fish*, **6(1)**, 16-26.

Grimm, M. P. and Klinge, M. (1996) Pike and some aspects of its dependence on vegetation. In: *Pike Biology and Exploitation* (pp. 125-156). Springer Netherlands.

He, X. and Kitchell, J.F. (1990) Direct and indirect effects of predation on a fish community: a whole-lake experiment. *Transactions of the American Fisheries Society*, **119(5)**, 825-835.

Healy, A. (1956) Pike (*Esox lucius* L.) in three Irish lakes. Royal Dublin Society.

Hein, C. L., Öhlund, G. and Englund, G. (2011) Dispersal through stream networks: modelling climate-driven range expansions of fishes. *Diversity and Distributions*, **17 (4)**, 641-651.

Heins, D.C., Knoper, H. and Baker, J.A. (2016) Consumptive and non-consumptive effects of predation by introduced northern pike on life-history traits in three spine stickleback. *Evolutionary Ecology Research*, **17(3)**, 355-372.

Hesthagen, T., Sandlund, O. T., Finstad, A. G. and Johnsen, B. O. (2015) The impact of introduced pike (*Esox lucius* L.) on allopatric brown trout (Salmo trutta L.) in a small stream. *Hydrobiologia*, **744 (1)**, 223-233.

Jepsen, N., Pedersen, S. and Thorstad, E. (2000) Behavioural interactions between prey (trout smolts) and predators (pike and pikeperch) in an impounded river. *River Research and Applications*, **16 (2)**, 189-198.

Kekäläinen, J., Niva, T. and Huuskonen, H. (2008) Pike predation on hatchery-reared Atlantic salmon smolts in a northern Baltic river. *Ecology of Freshwater Fish*, **17(1)**, 100-109.

Kelly, F. and Connor, L. (2007) *WFD Surveillance Monitoring - Fish in Lakes 2007*. Central Fisheries Board report.

Kelly, F.L., Connor, L., Coyne, J., Morrissey, E., Corcoran, W., Cierpial, D., Delanty, K., McLoone, P., Matson, R., Gordon, P., O' Briain, R., Rocks, K., O' Reilly, S., Kelly K., Puttharee, D., McWeeney, D., Robson S. and Buckley, S. (2017) *Fish Stock Survey of Lettercraffroe Lough, September 2016*. Inland Fisheries Ireland.

Kelly, F.L., Matson, R., Delanty, K., Connor, L., O'Briain, R., Gordon, P., Corcoran, W., McLoone, P., Connor, L., Coyne, J., Morrissey, E., Cierpal, D., Rocks, K., Buckley, S., Kelly, K., McWeeney, D. and Puttharee, D. (2017) *Sampling Fish in Rivers 2016*. National Research Survey Programme, Inland Fisheries Ireland.

Kelly, F.L., McLoone, P., Connor, L., Coyne, J., Morrissey, E., Corcoran, W., Cierpial, D., Delanty, K., Matson, R., Gordon, P., O' Briain, R., Rocks, K., O' Reilly, S., Kelly K., Puttharee, D., McWeeney, D., Robson S. and Buckley, S. (2017) Fish Stock Survey of Levally Lough, September 2016. National Coarse Fish and Pike Programme, Inland Fisheries Ireland.

Kelly, F.L., Matson, R., Delanty, K., Connor, L., O'Briain, R., Gordon, P., Corcoran, W., McLoone, P., Connor, L., Coyne, J., Morrissey, E., Cierpal, D., Rocks, K., Buckley, S., Kelly, K., McWeeney, D. and Puttharee, D. (2017) Sampling Fish in Rivers 2016. National Research Survey Programme. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland.

Kelly, F.L., Matson, R., Harrison A., Connor, L., Feeney, R., Morrissey, E., O'Callaghan, R., Wogerbauer, C. and Rocks, K. (2011) Water Framework Directive Fish Stock Survey of Rivers in the Western River Basin District. Inland Fisheries Ireland, Swords Business Campus, Swords, Co. Dublin, Ireland.

Kelly, F.L., Connor, L., Morrissey, E., Coyne, J., Matson, R., Feeney, R. and Rocks, K. (2014*) Water Framework Directive Fish Stock Survey of Lettercraffrroe Lough, September 2013*. Inland Fisheries Ireland.

Kelly, F.L., Connor, L., Morrissey, E., Coyne, J., Matson, R., Feeney, R. and Rocks, K. (2011*) Water Framework Directive Fish Stock Survey of Lettercraffrroe Lough, September 2010*. Inland Fisheries Ireland.

Kelly, F.L., Harrison, A.J., Allen, M., Connor, L. and Rosell, R. (2012) Development and application of an ecological classification tool for fish in lakes in Ireland. *Ecological Indicators*, **18**, 608-619.

Kelly, F.L., Harrison, A., Connor, L., Allen, M., Rosell, R. and Champ, T. (2008) *FISH IN LAKES Task 6.9: Classification tool for Fish in Lakes. FINAL REPORT*. Central Fisheries Board, NSSHARE project.

Kennedy, M. and Fitzmaurice, P. (1971) Growth and food of brown trout *Salmo trutta* (L.) in Irish waters. *Proceedings of the Royal Irish Academy*, **71(B) (18)**, 269-352.

Klemetsen, A., Amundsen, P.A., Dempson, J.B., Jonsson, B., Jonsson, N., O'connell, M.F. and Mortensen, E. (2003) Atlantic salmon *Salmo salar* L., brown trout *Salmo trutta* L. and Arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. *Ecology of freshwater fish*, **12(1)**, 1-59.

Lydon, K. and Smith, G. (2014) CORINE Landcover 2012 Ireland. Final Report. Environmental Protection Agency.

Matson, R., Delanty, K., Shephard, S., Coghlan, B., and Kelly, F. (2017) Moving from multiple pass depletion to single pass timed electrofishing for fish community assessment in wadeable streams. *Fisheries Research*, **198**, 99-108.

Nicholson, M. E., Rennie, M. D. and Mills, K. H. (2015) Apparent extirpation of prey fish communities following the introduction of Northern Pike (*Esox lucius*) *The Canadian Field-Naturalist*, **129 (2)**, 165-173.

Nilsson, P. A. and Brönmark, C. (2000) Prey vulnerability to a gape-size limited predator: behavioural and morphological impacts on northern pike piscivory. *Oikos*, **88 (3)**, 539-546.

NPWS (2005) Site synopsis: Connemara Bog Complex. Site code: 2034 Site Synopsis report, National Parks and Wildlife Service.

NS 2 (2010) *Freshwater Pearl Mussel, Second Draft, Owenriff Sub-Basin Management Plan*. Produced by NS 2, funded by DEHLG.

O' Reilly, P. (2007) *Loughs of Ireland. A Flyfisher's Guide*. 4th Edition. Merlin Unwin Books.

O' Grady, M.F. (1981) *A Study of Brown Trout (Salmo trutta L.) Populations in Selected Irish Lakes*. Ph.D. Thesis, National University of Ireland.

Patankar, R., Von Hippel, F. A. and Bell, M. A. (2006) Extinction of a weakly armoured three spine stickleback (*Gasterosteus aculeatus*) population in Prator Lake, Alaska. *Ecology of Freshwater Fish*, **15 (4)**, 482-487.

Pedreschi, D., Mariani, S., Coughlan, J., Voigt, C.C., Caffrey, J., O' Grady, M. and Kelly-Quinn, M. (2014) *Trophic Flexibility and Diet of Pike (Esox Lucius l.) in Ireland*. Layman's report. Inland Fisheries Ireland.

Pinkas, L.. and Iverson, I. L. K. (1971) Food habits of albacore, bluefin tuna and bonito in Californian waters. California Department of Fish and Game. *Fish Bulletin*, **152**, 1-105.

Sepulveda, A. J., Rutz, D. S., Ivey, S. S., Dunker, K. J., & Gross, J. A. (2013) Introduced northern pike predation on salmonids in southcentral Alaska. *Ecology of Freshwater Fish*, **22 (2)**, 268-279.

SNIFFER (2011) *River Fish Classification Tool: Science Work*. WFD68c, Phase 3, Final Report. Scotland and Northern Ireland Forum for Environmental Research.

Spens, J., Englund, G., and Lundqvist, H. (2007) Network connectivity and dispersal barriers: using geographical information system (GIS) tools to predict landscape scale distribution of a key predator (*Esox lucius*) among lakes. *Journal of Applied Ecology*, **44 (6)**, 1127-1137

Spens, J., and Ball, J. P. (2008) Salmonid or non salmonid lakes: predicting the fate of northern boreal fish communities with hierarchical filters relating to a keystone piscivore. *Canadian Journal of Fisheries and Aquatic Sciences*, **65 (9)**, 1945-1955.

Vehanen, T. and Hamari, S. (2004) Predation threat affects behaviour and habitat use by hatchery brown trout (*Salmo trutta* L.) juveniles. *Hydrobiologia*, **525(1)**, pp.229-237.

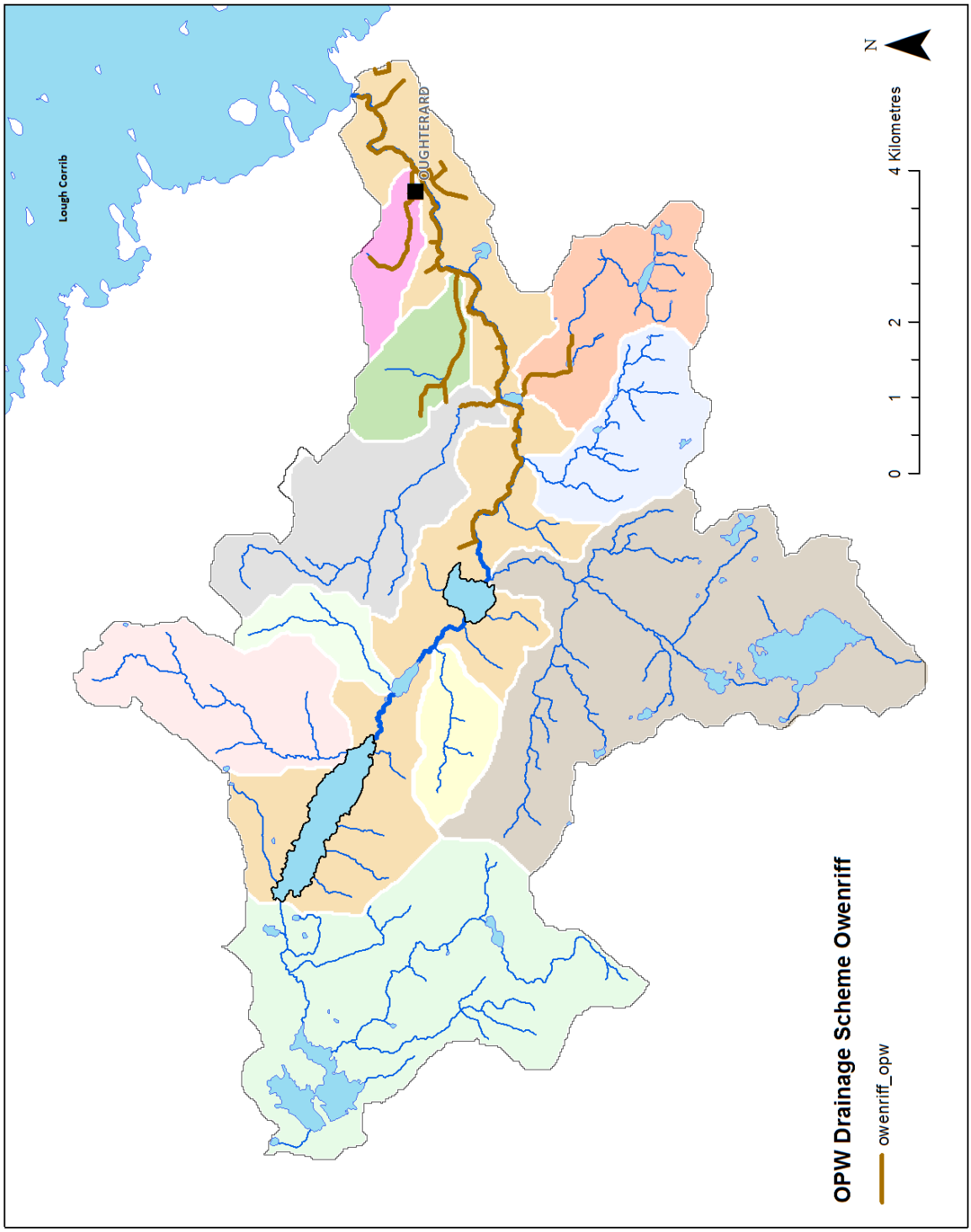
Venturelli, P. A. and Tonn, W. M. (2006) Diet and growth of northern pike in the absence of prey fishes: initial consequences for persisting in disturbance-prone lakes. *Transactions of the American Fisheries Society*, **135 (6)**, 1512-1522.

Went, A.E., (1957) The pike in Ireland. *The Irish Naturalists' Journal*, pp.177-182.

WRFB (2006) *Bathymetric survey of lakes in the Western Regional Fisheries Board Area*. A Water Framework Directive Project, 2006.

WRBD (2008) *Catchment Wide Fish Survey for the Owenriff River*. The Western Regional Fisheries Board, A Western River Basin District Project Report.

Appendix 1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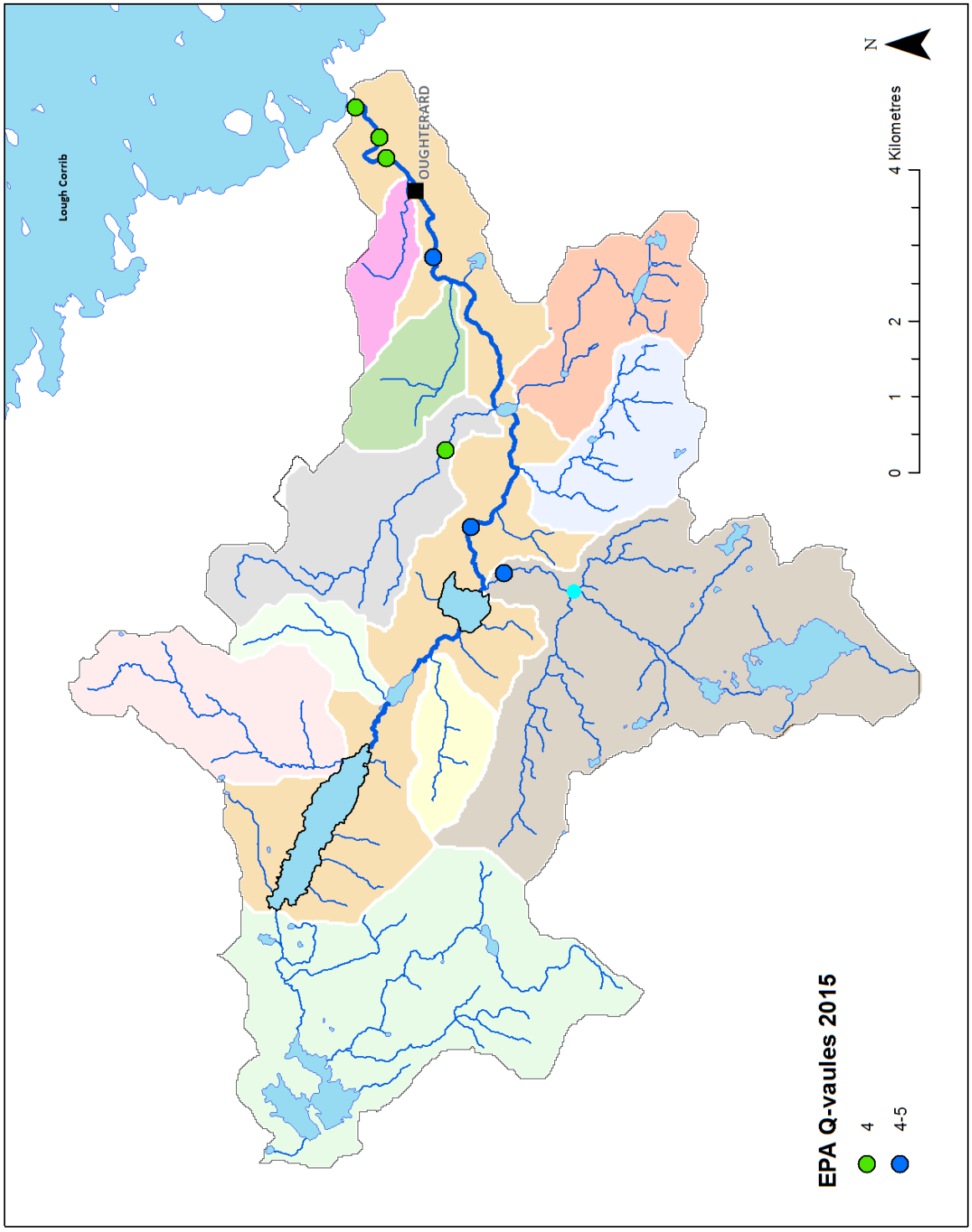
Appendix 2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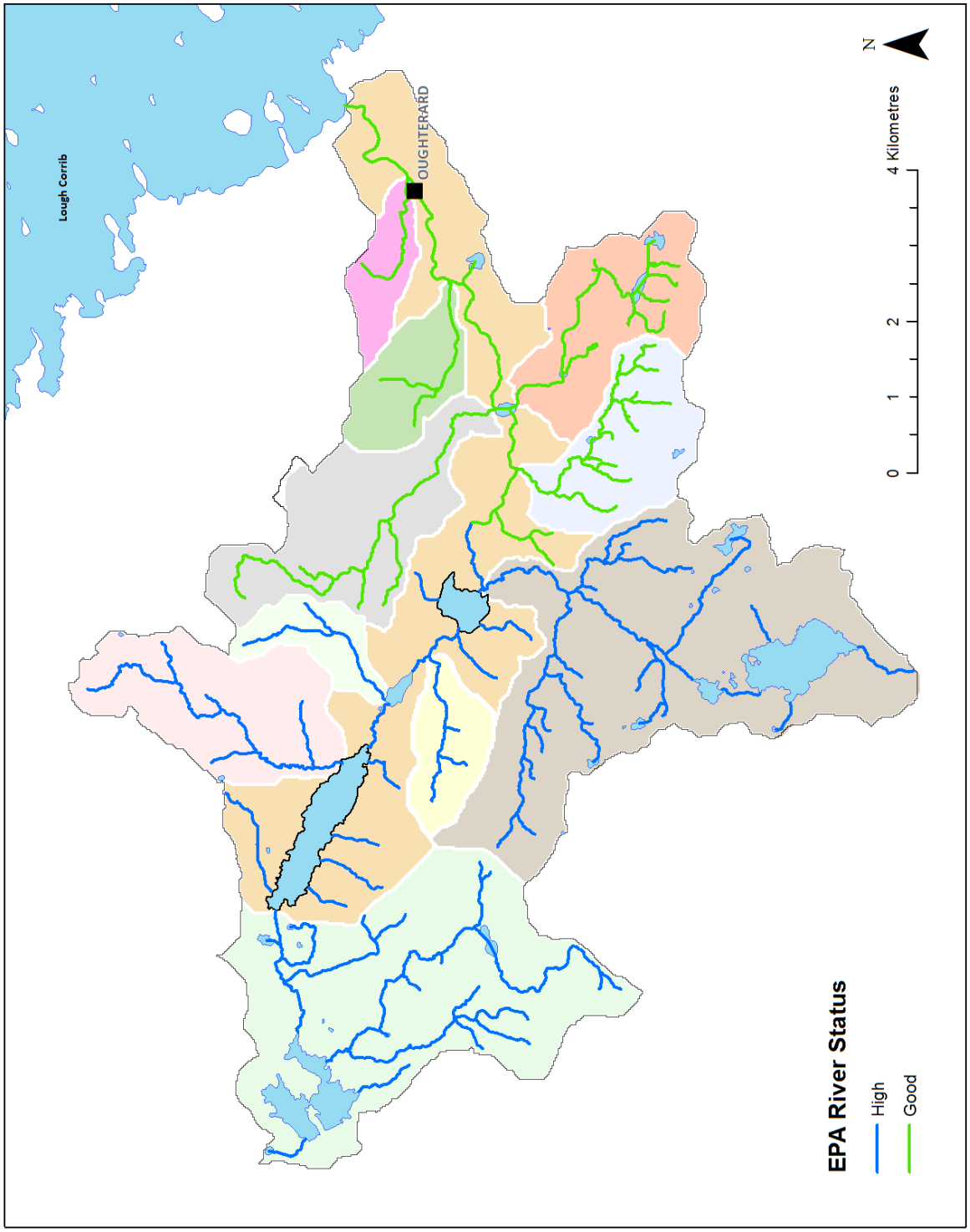
Appendix 3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EPA River Status
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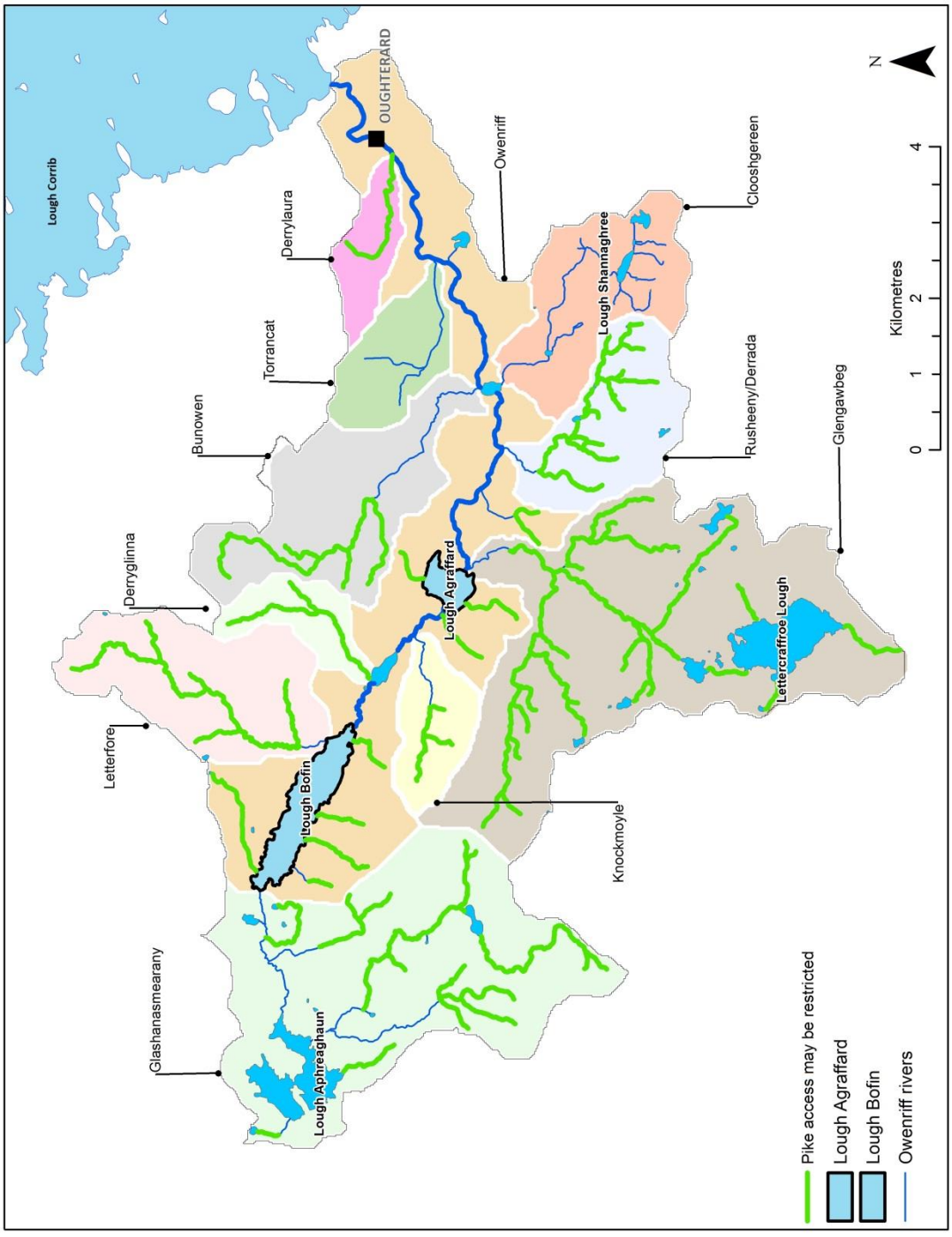
Good

Appendix 4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Owenriff
Clooshgereen
Derrylaura
Lough Shannaghree
Torrancat
Bunowen
Rusheeny/Derrada
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Derryglinna
Lough Agraffard
Lettercraffroe Lough
Letterfore
Lough Bofin
Knockmoyle
Glashanasmearany
Lough Aphreaghaun
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Pike access may be restricted
Lough Agraffard
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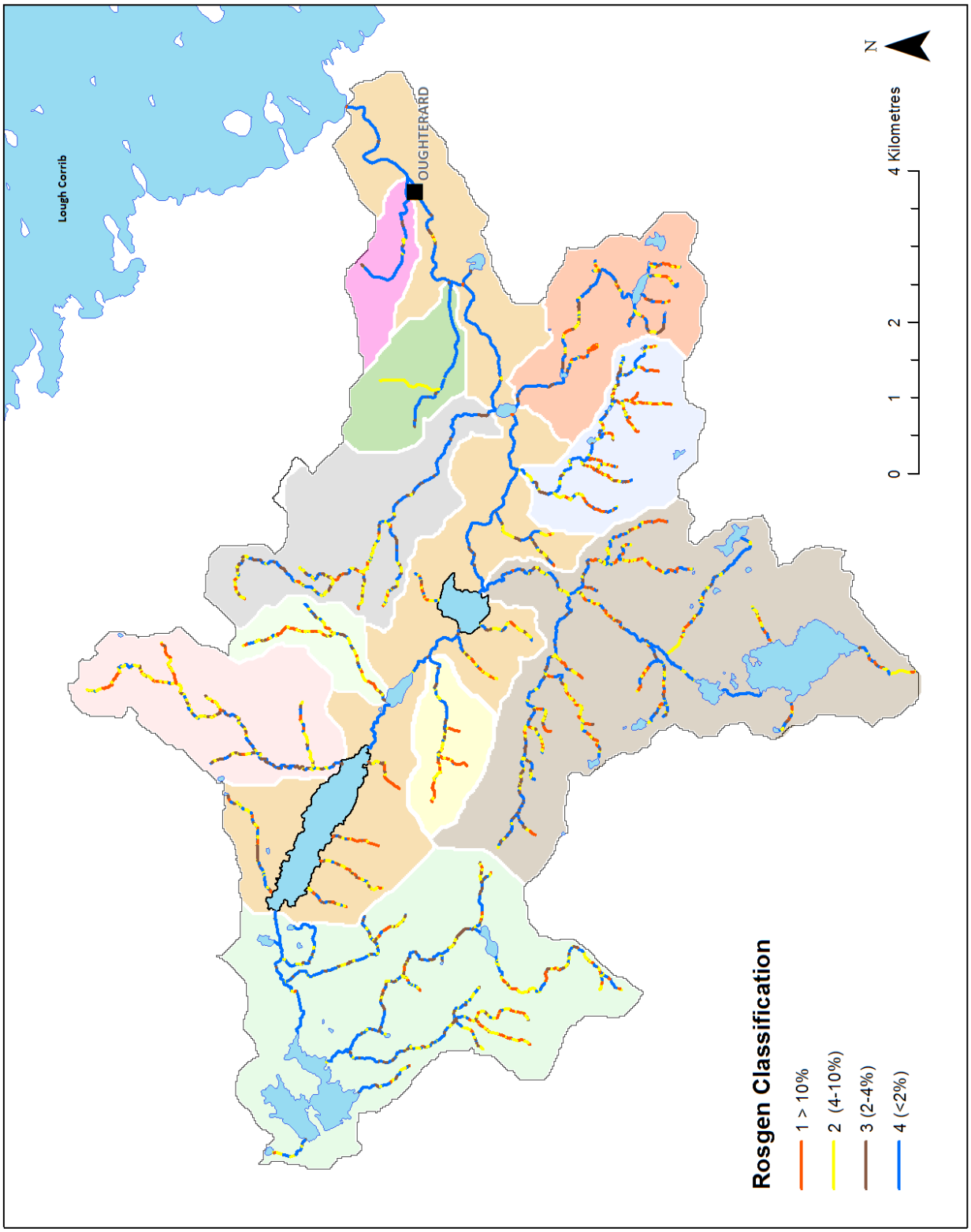
Owenriff rivers

Appendix 5


Lough Corrib
OUGHTERARD
N
0
1
2
4 Kilometres
Rosgen Classification
1 > 10%
2 (4-10%)
3 (2-4%)
4 (<2%)

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