Sampling Fish for the Water Framework Directive

Summary Report 2010

Iascach Intíre Éireann
Inland Fisheries Ireland

Sampling Fish for the Water Framework Directive

A Summary of Inland Fisheries Irelands' Surveillance Monitoring for Fish in Lakes, Rivers and Transitional Waters 2010

Summary Report 2010

Inland Fisheries Ireland CEO's Statement

The Water Framework Directive (WFD) was introduced in December 2000 with the broad aims of providing a standardised approach to water resource management throughout Europe and promoting the protection and enhancement of healthy aquatic ecosystems. The Directive, transposed into Irish Law in December 2003, requires Member States to protect those water bodies that are already of Good or High ecological status and to restore all water bodies that are degraded in order that they achieve at least Good ecological status by 2015.

The dedicated WFD staff based at IFI Swords work closely with colleagues within Inland Fisheries Ireland and with staff from other national agencies, academic institutions and our parent Department, the Department of Communication, Energy and Natural Resources.

During 2010, the WFD surveillance monitoring programme was influenced by the difficult circumstances surrounding the current economic climate. The recruitment embargo in particular has had a significant impact, with reduced staff numbers limiting the ability to complete surveys on larger sites; however, despite this, concerted efforts by the WFD team in IFI Swords, along with the help of many staff from the regional IFI offices, has ensured that the key objectives were still met and are summarised in this report.

I am extremely delighted to have such an experienced, dedicated and talented team of scientists working within the WFD team in IFI, Swords; however, it is gratefully acknowledged that without the support and commitment of the management and staff in the IFI regional offices during 2010, it would not have been possible to complete many of the key objectives reported in this document.

I would like to congratulate all who have contributed to the significant level of work which was undertaken in 2010 under the Water Framework Directive fish surveillance monitoring programme, the key elements of which are reported in this document, and wish them continued success in 2011.

Ciaran Byrne

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Dr Ciaran Byrne
CEO, Inland Fisheries Ireland

July 2011

Foreword

Welcome to the Inland Fisheries Ireland Sampling Fish for the Water Framework Directive – Summary Report 2010.

Inland Fisheries Ireland (previously the Central and Regional Fisheries Boards) has been assigned the responsibility by the Environmental Protection Agency (EPA) for delivering the fish monitoring element of the WFD in Ireland. Surveillance monitoring sites are set out in the WFD Monitoring Programme published by the EPA in 2006 and the fish monitoring requirements are extensive, with over 300 water bodies, encompassing rivers, lakes and transitional waters, being surveyed in a three year rolling programme. Although the surveillance monitoring programme for rivers and transitional waters was delayed by one year, the three subsequent years (2007 – 2009) have seen a huge effort by the team of scientists within IFI to achieve the three year goals, and I'm delighted to report a total of 70 lakes, 68 transitional waters and 137 river sites were surveyed in the first surveillance monitoring cycle.

The first year of the second three year cycle began in 2010 with another extensive surveillance monitoring programme. A total of 25 lakes, 25 transitional waters and 43 river sites were surveyed, and over 50,000 fish captured and examined. All fish have been identified, counted and a representative sub-sample has been measured, weighed and aged. A further sub-sample of fish was retained for laboratory analysis of stomach contents, sex and parasitism. Once fieldwork finished in early November, IFI WFD staff spent the winter months processing this large volume of fish samples.

All water bodies surveyed have been assigned a draft ecological status class (High, Good, Moderate, Poor or Bad) and these results have been submitted to the EPA for inclusion in River Basin Management Plans (RBMP). Future information from ongoing surveillance monitoring will evaluate the effectiveness of programmes of measures set out in these RBMPs.

The data collected to date during the first four years of surveillance monitoring for the WFD not only fulfils legislative requirements, but provides an invaluable source of information on fish species distribution and abundance for decision makers, angling clubs, fishery owners and other interested parties. Preliminary reports for each water body are available on the WFD fish website (www.wfdfish.ie) and these will be replaced by more detailed reports on each water body in 2011. The huge amount of data generated has been collated and a new GIS database has been developed to store and display this information. An interactive WFD fish survey map viewer is also available on the WFD fish website, containing fish survey data from 2007 to 2009. Data from the 2010 surveillance monitoring programme will be available on this map viewer in 2011.

The recent organisational change from the Central and Regional Fisheries Boards to Inland Fisheries Ireland in 2010, within a challenging economic climate, necessitates a strong business focus on project management to ensure that Inland Fisheries Ireland continues to deliver against the requirements of the WFD fish monitoring programme. We also continue to see rapid changes in our aquatic environment; conservation and protection of this resource is of the highest priority.

Lastly I would like to thank all those that contributed to this report and I wish the IFI WFD team every success for the year ahead.

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Dr Cathal Gallagher,
Head of Function, Research & Development

Inland Fisheries Ireland,
July 2011

Executive Summary

The Water Framework Directive (WFD) (2000/60/EC) came into force in 2000 and was subsequently transposed into Irish law in 2003 (S.I. No. 722 of 2003), with the principal aim of preserving those water bodies where the ecological status is currently 'High' or 'Good', and restoring those water bodies that are currently impaired to achieve at least 'Good' ecological status in all water bodies by 2015.

A key step in this process is that each Member State must assess the current ecological status of surface water bodies (rivers, lakes and transitional waters) by monitoring a range of physical, chemical and biological quality elements including phytoplankton, macrophytes, phytobenthos, benthic invertebrates and fish. Ongoing monitoring of the ecological status of these surface waters will then aid in the development of programmes of measures designed to restore those water bodies that fail to meet the WFD requirement of Good ecological status.

Surveillance monitoring locations for all biological quality elements, including fish, have been set out in the WFD Water Monitoring Programme published by the Environmental Protection Agency (EPA) in 2006. Inland Fisheries Ireland has been assigned the responsibility by the EPA of delivering the fish monitoring requirements of the WFD in Ireland. Over 300 water bodies, encompassing rivers, lakes and transitional waters are surveyed in a three year rolling programme. In 2010, a comprehensive fish surveillance monitoring programme was conducted, with 43 river sites, 25 lakes and 25 transitional waters successfully surveyed throughout the country.

All surveys were conducted using a suite of European standard methods; electric-fishing is the main method used in rivers and various different net types are used in lakes and transitional waters. This report summarises the main findings of the 2010 surveillance monitoring programme and highlights the current status of each water body in accordance with the fish populations present.

Twenty-five lakes were surveyed during 2010, with a total of 17 fish species (sea trout are included as a separate 'variety' of trout) and one type of hybrid being recorded. Eel was the most common fish species recorded, being found in 22 of the 25 lakes surveyed (88%). This was followed by brown trout, perch and pike which were present in 80%, 68% and 44% of lakes respectively. In general, salmonids were distributed towards the north and west of the country. Sea trout were only captured in four lakes in the west (Beltra Lough, Kylemore Lough, Ardderry Lough and Glencar Lough). Char were recorded in four lakes in the NWIRBD and WRBD: Glen Lough, Kylemore Lough, Shindilla Lough and Ardderry Lough. Perch, followed by pike were the most widely distributed non-native species recorded during the 2010 surveillance monitoring programme, with perch being present in 17 and pike being present in 11 out of the 25 lakes surveyed. The status of non-native fish species varies throughout Ireland, with much of the north-west and many areas in the west, south-west and east of Ireland still free from non-native introductions.

An ecological classification tool for fish in lakes (FIL1) was developed for the island of Ireland using Republic of Ireland and Northern Ireland data collected during the NSSHARE Fish in Lakes project (Kelly *et al*., 2008b). This tool was further developed during 2010 (FIL2) to make it fully WFD compliant and all lakes surveyed during 2010 have been assigned a draft ecological status based on the fish populations present; six were classified as High, eight were classified as Good, one was classified as Moderate and ten were classified as Poor/Bad. The geographical variation in ecological status reflects the change in fish communities (mainly salmonids) from upland lakes with little human disturbance to the fish communities associated with lowland lakes subject to more intensive anthropogenic pressures (mainly percids and cyprinids).

A total of 43 river sites were surveyed during 2010 using boat-based electric-fishing gear for the larger sites and hand-set electric-fishing gear for the smaller sites. A total of 17 fish species (sea trout are included as a separate 'variety' of trout) and one type of hybrid were recorded. Species richness ranged from ten in the River Blackwater (Lismore) site to only one species in the Screeb River site.

Brown trout was the most common species recorded, being present in 79% of sites surveyed, followed by eel (77%), salmon (67%) and minnow (51%). Brown trout and salmon population densities were greater in wadeable streams using bank-based electric-fishing gear compared to deeper rivers surveyed using boat-based electric-fishing gear. This is mainly due to the preference for juvenile salmonids to inhabit shallow riffle areas; however, it may also be due in some part to the relative catch efficiency of bank-based electric-fishing surveys compared with boat-based electric fishing. Non-native fish species, similar to those found in lakes, are also present in many Irish rivers, with a large variation in distribution and abundance among species.

An ecological status classification tool for fish in Irish rivers has recently been developed, broadly based on the 'Fisheries Classification Scheme 2' used by the Environment Agency in England and Wales. The new tool, 'FCS2 Ireland', has updated and improved the original FCS2 model using data from Northern Ireland and the Republic of Ireland to produce a WFD compliant statistical model for assigning ecological status to Irish rivers based on fish population parameters. This tool, along with expert opinion, was used to classify 39 of the 43 river sites surveyed during 2010; four river sites were classified as High, 17 were classified as Good, 18 were classified as Moderate, zero were classified as Poor and zero were classified as Bad ecological status. Four sites were not classified due to river conditions during the time of the survey being inappropriate for collection of reliable data.

Twenty-five transitional water bodies were surveyed during 2010, split into three categories based on their salinity and connectivity to the sea; Transitional water bodies (22), Freshwater Tidal water bodies (1) and Lagoon water bodies (2). A total of 55 fish species (sea trout are included as a separate 'variety' of trout) were recorded. Flounder was the most common fish species, being recorded in all water bodies surveyed. This was followed by sand goby (96%), eel (88%) and thick-lipped grey mullet (72%). Species richness among the sites surveyed ranged from 23 in North Channel Great

Island (Greater Cork Harbour) to only three in Glashaboy Estuary. Species of particular angling importance, such as cod, pollack and sea trout were recorded in 56%, 32% and 28% of transitional water bodies respectively.

A new ecological classification tool (Transitional Fish Classification Index – TFCI) for fish in transitional waters has been developed for the Island of Ireland (Ecoregion 17) using IFI and Northern Ireland Environment Agency (NIEA) data. Using the TFCI, all 25 transitional waters surveyed in 2010 were assigned a draft ecological status class. Thirteen water bodies were classified as Good, nine were classified as Moderate, two were classified as Poor and one was classified as Bad ecological status.

In addition to the Water Framework Directive requirements of information on ecological status, the work conducted in 2010 provides more comprehensive information on fish stocks in a large number of Irish surface waters. For example, an investigation of the current status of the pollan population in Lough Ree was also conducted. This will be of interest to many parties and will aid in the development of appropriate fisheries management plans.

Project Personnel

This report was written and researched by Dr. Fiona Kelly, Dr. Andrew Harrison, Ms. Lynda Connor, Dr. Ronan Matson, Ms. Emma Morrissey, Mr. Rory Feeney, Ms. Ciara Wogerbauer, Mr. Kieran Rocks and Ms. Roisin O'Callaghan, Inland Fisheries Ireland (IFI), under the direction of Dr. Cathal Gallagher, Head of Research and Development as part of the Water Framework Directive (WFD) Fish Surveillance Monitoring Programme, 2010 to 2012. Ms Grainne Hanna and Mr Kevin Gallagher assisted with fieldwork during the transitional water surveys.

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The authors wish to gratefully acknowledge the help and co-operation of the Directors and their staff from the seven regional IFI river basin district offices and also all their colleagues in IFI, Swords. Cooperation and assistance from the Department of Culture, Arts and Leisure (DCAL) and the Agri-Food and Biosciences Institute for Northern Ireland (AFBINI) on cross border surveys is also gratefully acknowledged. The IFI 'Large Patrol Vessel' (LPV) was used for the Greater Cork Harbour surveys and the help and support from the crew is also acknowledged.

The authors would like to thank all land owners who provided site access for surveys. The angling clubs and associations on Loughs Lene, Bane, Rea, Lickeen and Atedaun are also gratefully acknowledged for their help and cooperation with site access and survey work.

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About Inland Fisheries Ireland

The fisheries service in Ireland has recently undergone a major organisational transition, following the government plan for the rationalisation of state agencies outlined in the 2009 budget. The eight separate fisheries organisations, comprising the Central Fisheries Board (CFB) and seven Regional Fisheries Boards (RFBs), recently merged into one single entity and became Inland Fisheries Ireland (IFI) on 1st July 2010. As a result of these changes, the previous administrative zones, the RFBs, have been realigned along the boundaries of River Basin Districts (RBDs) and in some cases transcend international boundaries (International River Basin Districts – IRBDs).

Inland Fisheries Ireland has strong regional structures responsible for each RBD, with the IFI headquarters in Swords, Co. Dublin operating alongside seven regional offices; Eastern River Basin District (IFI, Blackrock), South-Eastern River Basin District (IFI, Clonmel), South-Western River Basin District (IFI, Macroom), Shannon International River Basin District (IFI, Limerick), Western River Basin District (IFI, Ballina and IFI, Galway) and North-Western International River Basin District (IFI, Ballyshannon).

Inland Fisheries Ireland is responsible for the protection, management and conservation of the inland fisheries resource across the country. Ireland has over 70,000 kilometres of rivers and streams and 144,000 hectares of lakes all of which fall under the jurisdiction of IFI. The agency is also responsible for sea angling in Ireland.

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1. INTRODUCTION

In December 2000, the European Union introduced the Water Framework Directive (WFD) (2000/60/EC) as part of a new standardised approach for all Member States to manage their water resources and to protect aquatic ecosystems. The fundamental objectives of the WFD, which was transposed into Irish Law in December 2003 (Water Regulations S.I. No. 722 of 2003), are to protect and maintain the status of waters that are already of good or high quality, to prevent any further deterioration and to restore all waters that are impaired so that they achieve at least good ecological status by 2015. Many pollution reduction measures already in place as part of existing directives and national legislation will be evaluated, modified, and coordinated under the WFD to achieve these objectives.

A key step in the WFD process is for EU Member States to assess the health of their surface waters through national monitoring programmes. Monitoring is the main tool used to classify the status (high, good, moderate, poor or bad) of each water body (section of a river or other surface water). Once each country has determined the current status of their water bodies, ongoing monitoring then helps to track the effectiveness of measures needed to clean up water bodies and achieve good status. In accordance with national legislation, the Environmental Protection Agency (EPA) published, in 2006, a programme of monitoring to be carried out in Ireland in order to meet the legislative requirements of the WFD.

Water quality in Ireland has been assessed for many years by the EPA, principally on the basis of water chemistry and aquatic creatures such as insects, snails and shrimps. In the year 2000, the OECD criticised Ireland for placing too much emphasis on water quality and not enough on ecosystem quality. The WFD now requires that, in addition to the normal monitoring carried out by the EPA, other aquatic communities such as plants and fish populations must also be evaluated periodically in certain situations. WFD will also monitor human impacts on hydromorphology (i.e. the physical shape of river systems). These data collectively will be used to assess ecosystem quality.

The responsibility for monitoring fish has been assigned to Inland Fisheries Ireland (IFI) by the EPA (EPA, 2006). A national fish stock surveillance monitoring programme has been conducted since 2007 at specified locations over a three year rolling cycle. The monitoring programme includes over 300 sites, encompassing rivers, lakes and transitional waters (estuaries and lagoons). This programme will provide new information on the status of fish species present at these sites as well as on their abundance, growth patterns, and population demographics.

During the first three year surveillance monitoring cycle, from 2007 to 2009, a total of 70 lakes, 72 transitional waters and 134 river sites were surveyed, with over 70 fish species and 150,000 fish captured and examined.

The WFD fish surveillance monitoring programme in 2010 has again been extensive and 41 river sites, 25 lakes and 25 transitional water bodies were successfully surveyed nationwide. A team of scientists from the Research and Development section of IFI Swords carried out the monitoring surveys in conjunction with staff from the regional IFI river basin district offices. Staff from the Department of Culture, Arts and Leisure (DCAL) and the Agri-Food and Biosciences Institute for Northern Ireland (AFBINI) were also involved in surveys of four cross border lakes (see Table 2.1). The surveys were conducted using a suite of European standard methods; electric fishing is the main survey method used in rivers and various netting techniques are being used in lakes and estuaries. Survey work was conducted between June and November, which is the optimum time for sampling fish in Ireland. Although relatively favourable weather conditions, particularly during the early field season, facilitated the completion of most surveys, reductions in staffing levels and resources resulted in some river sites and transitional water bodies planned for 2010 being deferred until 2011.

This report summarises the main findings of the fish stock surveys in all water bodies (lakes, rivers and transitional waters) surveyed during 2010 and reports the current status of the fish stocks in each.

One of the main objectives of the WFD monitoring programme is to assign ecological status to each water body. The ecological status class assigned to each water body surveyed during 2010, using newly developed ecological classification tools, are also presented here.

Detailed reports on all water bodies surveyed are available to download on the dedicated WFD fish website (www.wfdfish.ie).

2. STUDY AREA

2.1 Lakes

Twenty-five lake water bodies, including four cross border lakes, ranging in size from 4.3ha (Lough Mushlin) to 10,500ha (Lough Ree), were surveyed between June and October 2010.The selection of lakes surveyed encompassed a range of lake types (10 WFD designated typologies) (EPA, 2005; Appendix 1) and trophic levels, and were distributed throughout four different RBDs (Table 2.1, Fig. 2.1).

Three lakes were surveyed in the Eastern River Basin District (ERBD) (Annagh/White Lough, Lough Bane and Lough Lene). Four lakes were surveyed in the Shannon International River Basin District (ShIRBD), ranging in size from 84.2ha (Lickeen Lough) to 10,500ha (Lough Ree).Six lakes were surveyed in the North Western International River Basin District (NWIRBD), ranging in size from 4.3ha (Lough Mushlin) to 3218ha (Upper Lough Erne),and twelve lakes were surveyed in the Western River Basin District (WRBD), ranging in size from 10.4ha (Lough Nambrackmore) to 403ha (Beltra Lough). Summary details of all lakes surveyed in 2010 are shown in Table 2.1.

Table 2.1. Summary details of lakes surveyed for the WFD fish surveillance monitoring programme, June to October 2010 (* indicates cross border lakes).

Lake name	Water body code	Catchment	Easting	Northing	WFD Typology	Area (ha)	Mean depth (m)	Max depth (m)
ERBD								
Annagh/White	EA_07_258	Boyne	251007.83	273248.22	11	25.1	>4.0	18.0
Bane	EA_07_270	Boyne	254631.66	271497.58	12	75.4	>4.0	16.0
Lene	EA_07_274	Boyne	251910.54	268363.59	8	416.2	>4.0	20.0
ShIRBD								
Atedaun	SH_27_108	Fergus	129714.71	188473.91	9	37.9	2.3	7.0
Lickeen	SH_28_85	Inagh	116645.75	190840.23	8	84.2	>4.0	20.0
Ree	SH_26_750a	Shannon	202947.00	253041.00	12	10500.0	6.2	36.0
Urlaur	SH_26_689	Shannon	151235.00	288954.00	10	114.9	<4.0	11.0
NWIRBD								
Erne Upper*	NW_36_672	Erne	236752.00	322893.00	6	3218	<4.0	21.0
Glen	NW_38_22	Lackagh	210410.57	429362.52	4	167.7	4.9	14.1
Lattone*	NW_35_143	Drowes	200035.00	345421.00	7	32.8	6.9	14.7
Macnean Lower*	NW_36_445	Erne	210676.00	337835.00	6	471.0	1.5	12.7
Macnean Upper*	NW_36_673	Erne	204948.79	339084.60	8	644.0	5.2	22.7
Mushlin	NW_36_272	Erne	262457	301037	9	4.3	<4.0	2.2
WRBD								
Ardderry	WE_31_76	Coastal	96967.00	246051.00	4	81.1	>4.0	12.0
Aughrusbeg	WE_32_436	Coastal	55841.47	258298.63	7	50.2	<4.0	14.0
Beltra	WE_32_452	Newport	107191.00	298358.00	12	403.0	>4.0	26.0
Glenade	WE_35_156	Garvogue	182424.84	346452.60	6	73.6	<4.0	11.5
Glencar	WE_35_139	Drumcliff	175368.39	343290.95	12	114.6	>4.0	19.0
Kylemore	WE_32_509b	Dawros	76904.23	258455.28	4	134.1	>4.0	30.0
Lettercraffroe	WE_30_344	Corrib	105966.74	237374.25	2	82.4	2.8	17.8
Maumwee	WE_30_343	Corrib	97729.00	248780.00	1	27.6	2.1	8.8
Nambrackmore	WE_31_16	Coastal	71956.00	245252.00	1	10.4	2.1	10.0
Rea	WE_29_194	Kilcolgan	161513.31	215479.19	10	310.0	3.9	23.0
Ross	WE_30_345	Corrib	119813.49	236099.69	12	139.2	<4.0	14.0
Shindilla	WE_31_171	Coastal	95543.00	245916.00	4	65.3	>4.0	22.0

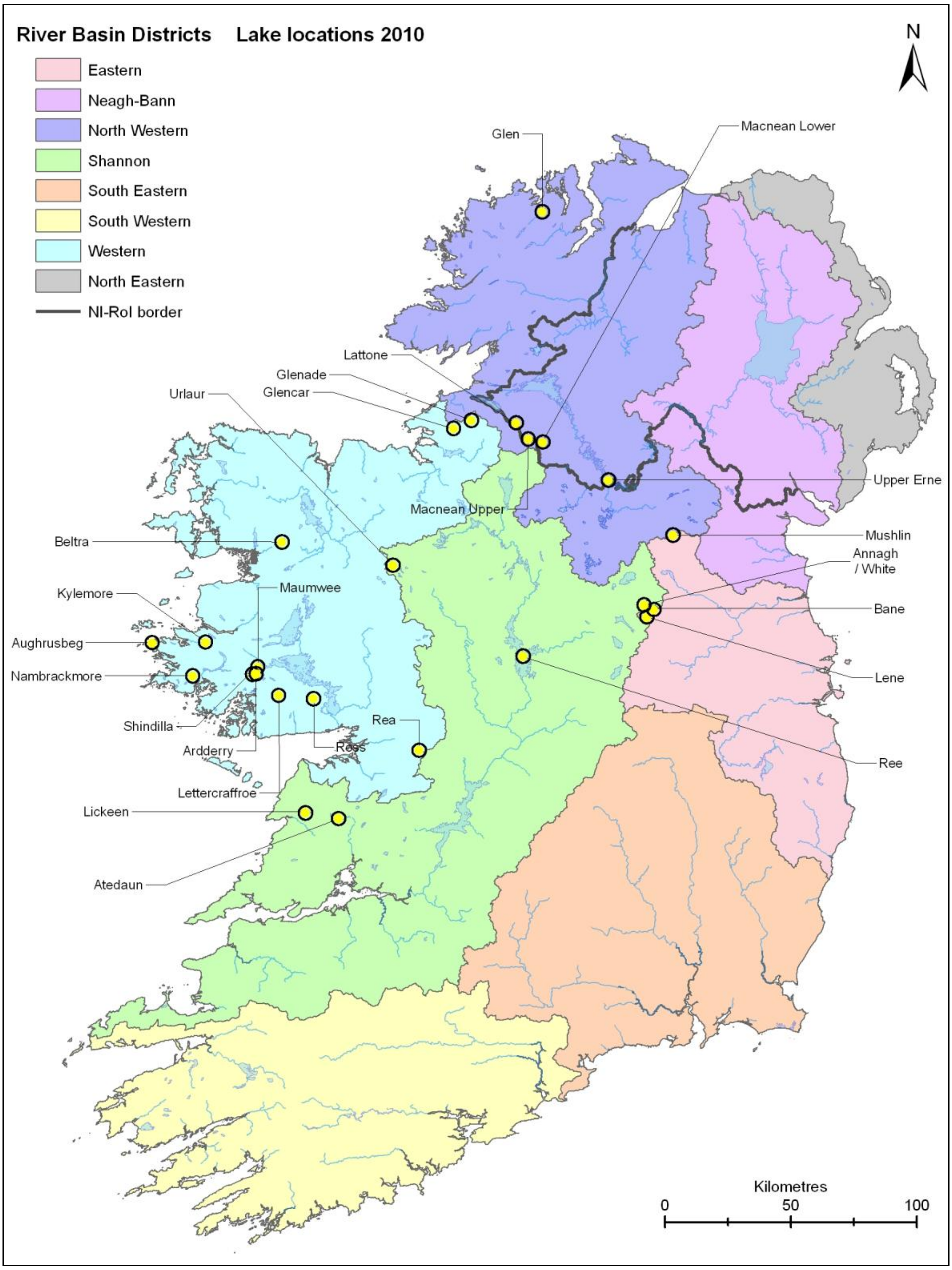

Fig. 2.1. Location of the 25 lakes surveyed for the WFD fish surveillance monitoring programme, June to October 2010

2.2 Rivers

Forty-three river sites, ranging in surface area from 214.5m^2 (Gowran River, Kilkenny) to 45,628m^2 (Shannon at Ballyleague), were surveyed between May and August 2010. Catchments encompassing each river water body were classified according to size as follows; <10km^2, <100km^2, <1000km^2 and <10000km^2. Sites were distributed throughout all seven RBDs within Ireland (Table 2.2, Table 2.3 and Fig. 2.2).

Three river sites were surveyed in the ERBD, ranging in surface area from 381m^2 (Avonbeg River) to 936m^2 (River Boyne). One river site was surveyed in the both the Neagh-Bann International River Basin District (NBIRBD) and NWIRBD; the Fane and Cullies Rivers, with surface areas of 375m^2 and 226.5m^2 respectively. Eight sites were surveyed in the South Eastern River Basin District (SERBD), ranging from 214.5m^2 on the Gowran River to 32,634m^2 on the River Suir at Kilsheelan Bridge. Seven sites were surveyed in the ShIRBD, ranging in surface area from 773.5m^2 on the Ballydangan River to 45,628m^2 on the River Shannon at Ballyleague Bridge. Eleven sites were surveyed in the South Western River Basin District (SWRBD), ranging in surface area from 284m^2 on the Cummeragh River to 23,975m^2 on the River Lee (Lee Fields). Twelve sites were surveyed in the WRBD, ranging in surface area from 305m^2 on the Owenriff River to 12,558m^2 on the River Moy at Bleanmore.

Summary details of each site's location and physical characteristics are given in Tables 2.2 and 2.3.

Table 2.2.Location and codes of river sites surveyed for the WFD fish surveillance monitoring programme, May to August 2010

River	Site name	Catchment	IFI site code	Waterbody code
ERBD wadeable sites				
Avonbeg	Greenan Br	Avoca	10A040800F	EA_10_99
ERBD non-wadeable sites				
Boyne	Boyne Br	Boyne	07B040200F	EA_07_990
NBIRBD wadeable sites				
Fane	Br d/s of Inniskeen	Fane	06F010650F	XB_06_8
NWIRBD wadeable sites				
Cullies	Br nr Kilbrackan Ho	Erne	36C030600F	NW_36_2032
SERBD wadeable sites				
Gowran	Br N of Goresbridge (S Channel)	Barrow	14G030300F	SE_14_1879
Slaney	Waterloo Br.	Slaney	12S020400F	SE_12_1524
SERBD non-wadeable sites				
Aherlow	Killardy Br	Suir	16A010900F	SE_16_540
Ara	Ara Br	Suir	16A030600F	SE_a6_2303
Barrow	Graiguenamanagh Br.	Barrow	14B013500F	SE_14_1909
Nore	Brownsbarn Br.	Nore	15N012400F	SE_15_1994_7
Nore	Quakers' Br.	Nore	15N010300F	SE_15_1018
Suir	Kilsheelan Br.	Suir	16S022700F	SE_16_4181_5
Suir	Knocknageragh Br.	Suir	16S020200F	SE_16_3997
ShIRBD non-wadeable sites				
Shannon (Upper)	Battle Br. (a)	Shannon Upper	26S020500Fa	SH_26_3090
Shannon (Upper)	Battle Br. (b)	Shannon Upper	26S020500Fb	SH_26_3090
Shannon (Upper)	Ballyleague Br. (a)	Shannon Upper	26S021600Fa	SH_26_4162
Shannon (Upper)	Ballyleague Br. (b)	Shannon Upper	26S021600Fb	SH_26_4162
Shannon (Upper)	Athlone d/s of Burgess Park	Shannon Upper	26S021720F	SH_26_1448_1
Shannon (Upper)	Clonmacnoise: at Jetty	Shannon Upper	26S021800F	SH_26_1448_3
Ballydangan	Br u/s Shannon R. confluence	Shannon Upper	26B140200F	SH_26_1341
SWRBD wadeable sites				
Cummeragh	U/s Owengarriff confluence	Cummeragh	21C040600F	SW_21_6162
Dalua	Ford and foobridge	Blackwater	18D010200F	SW_18_394
Finisk	Modelligo Br	Blackwater	18F020300F	SW_18_2774
Lee (Cork)	Inchinossig Br.	Lee	19L030100F	SW_19_928
Licky	Br. NE of Glenlicky	Blackwater	18L010100F	SW_18_2819
Owenreagh	Br. u/s Upper Lake	Laune	22O030400F	SW_22_2703
SWRBD non-wadeable sites				
Blackwater (Munster)	Lismore Br.	Blackwater	18B022600F	SW_18_2755
Blackwater (Munster)	Nohaval Br.	Blackwater	18B020200F	SW_18_450
Funshion	Br u/s Blackwater R confluence	Blackwater	18F051100F	SW_18_1836
Lee (Cork)	Lee fields	Lee	19L030700F	SW_19_1663
Owvane (Cork)	Lisheen / Piersons Br.	Owvane	21O070400F	SW_21_8048

Table 2.2 ctn. Location and codes of river sites surveyed for the WFD fish surveillance monitoring programme, May to August 2010

River	Site name	Catchment	IFI site code	Waterbody code
WRBD wadeable sites				
Abbert	Bridge at Bullaun	Corrib	30A010500F	WE_30_3424
Moy	Cloonbaniff Br.	Moy	34M020050F	WE_34_3035
Owenriff	D/s of Lough Agraffard	Corrib	30O020100F	WE_30_3396
WRBD non-wadeable sites				
Ballysadare	Ballysadare Br.	Ballysadare	35B050100F	WE_35_2107
Bonet	1.8 km d/s Dromahaire Bridge	Garvogue	35B060600F	WE_35_3842
Clare	Corrofin Br	Corrib	30C010800F	WE_30_258
Clare	Kiltroge Castle br.	Corrib	30C011300F	WE_30_258_5
Moy	At Bleanmore	Moy	34M020750F	WE_34_1935
Moy	Ford 2 km u/s Gweestion River	Moy	34M020650F	WE_34_1462_3
Owenmore (Sligo)	300 m u/s Unshin River confluence	Ballysadare	35O060900F	WE_35_2107
Robe	Akit Br.	Corrib	30R010600F	WE_30_3370_3
Screeb	d/s of Loughaunfree	Screeb	31S010570F	WE_31_2305

Table 2.3.Physical characteristics of river sites surveyed for the WFD fish surveillance monitoring programme, May to August 2010

River	Site name	Upstream catchment (Km^2)	Wetted width (m)	Surface area (m^2)	Mean depth (m)	Max depth (m)
ERBD wadeable sites						
Avonbeg	Greenan Br	72.1	8.12	381	0.31	0.56
ERBD Boat sites						
Boyne	Boyne Br	60.3	8.00	936	1.00	1.00
NBIRBD wadeable sites						
Fane	Br d/s of Inniskeen	234.3	7.98	375	0.23	0.82
NWIRBD wadeable sites						
Cullies	Br nr Kilbrackan Ho	110.4	5.03	227	0.17	0.40
SERBD wadeable sites						
Gowran	Br N of Goresbridge (S Channel)	42.1	4.77	215	0.20	0.55
Slaney	Waterloo Br.	77.7	11.59	522	0.20	0.58
SERBD non-wadeable sites						
Aherlow	Killardy Br	272.5	14.00	3248	0.65	1.80
Ara	Ara Br	83.2	6.80	864	0.90	1.00
Barrow	Graiguenamanagh Br.	2777.7	45.00	31365	1.75	2.00
Nore	Brownsbarn Br.	2419.3	40.50	23693	2.17	3.00
Nore	Quakers' Br.	84.4	8.00	2184	1.10	1.40
Suir	Kilsheelan Br.	2636.6	55.50	32634	1.75	3.00
Suir	Knocknageragh Br.	94.1	6.28	622	0.33	0.62
ShIRBD non-wadeable sites						
Shannon (Upper)	Battle Br. (a)	603.8	31.00	17577	1.00	1.50
Shannon (Upper)	Battle Br. (b)	604.6	32.67	6468	3.00	3.00
Shannon (Upper)	Ballyleague Br. (a)	2722.9	62.33	45628	1.50	1.50
Shannon (Upper)	Ballyleague Br. (b)	2779.5	87.50	34825	1.59	1.59
Shannon (Upper)	Athlone d/s of Burgess Park	4655.4	95.40	44170	2.54	4.50
Shannon (Upper)	Clonmacnoise: at Jetty	4919.8	89.33	37252	6.00	6.00
Ballydangan	Br u/s Shannon R. confluence	25.7	3.50	774	0.50	0.50
SWRBD wadeable sites						
Cummeragh	U/s Owengarriff confluence	19.8	6.32	284	0.27	0.59
Dalua	Ford and foobridge	86.6	10.78	485	0.21	0.51
Finisk	Modelligo Br	65.5	12.10	545	0.12	0.27
Lee (Cork)	Inchinossig Br.	31.8	9.33	411	0.26	0.71
Licky	Br. NE of Glenlicky	24.9	6.63	318	0.18	0.38
Owenreagh	Br. u/s Upper Lake	64.0	23.88	1075	0.16	0.66
SWRBD non-wadeable sites						
Blackwater (Munster)	Lismore Br.	2381.8	42.20	15530	1.83	3.00
Blackwater (Munster)	Nohaval Br.	89.0	10.17	2033	0.23	0.57
Funshion	Br u/s Blackwater R confluence	380.5	11.50	3151	1.07	1.50
Lee (Cork)	Lee fields	1184.0	45.67	23975	1.25	2.00
Owvane (Cork)	Lisheen / Piersons Br.	71.6	16.50	4340	0.56	1.70

Table 2.3 ctn. Physical characteristics of river sites surveyed for the WFD fish surveillance monitoring programme, May to August 2010

River	Site name	Upstream catchment (km^2)	Wetted width (m)	Surface area (m^2)	Mean depth (m)	Max depth (m)
WRBD wadeable sites						
Abbert	Bridge at Bullaun	211.9	7.92	356	0.12	0.20
Moy	Cloonbaniff Br.	16.1	7.95	358	0.30	0.70
Owenriff	D/s of Lough Agraffard	44.1	6.775	305	0.28	0.60
WRBD non-wadeable sites						
Ballysadare	Ballysadare Br.	641.9	24.60	7872	1.00	1.00
Bonet	1.8 km d/s Dromahaire Br.	292.2	21.3	6326	1.50	2.00
Clare	Corrofin Br.	704.3	19.00	6118	1.30	1.40
Clare	Kiltroge Castle Br.	1072.7	14.6	3416	0.53	0.60
Moy	At Bleanmore	949.0	39.00	12558	1.25	2.50
Moy	Ford 2 km u/s Gweestion River	558.9	30.17	10981	0.90	1.50
Owenmore (Sligo)	300m u/s Unshin confluence	416.3	23.33	3197	0.92	2.00
Robe	Akit Br.	253.7	16.25	7703	1.33	2.50
Screeb	d/s of Loughaunfree	28.2	17	2499	1.50	2.50

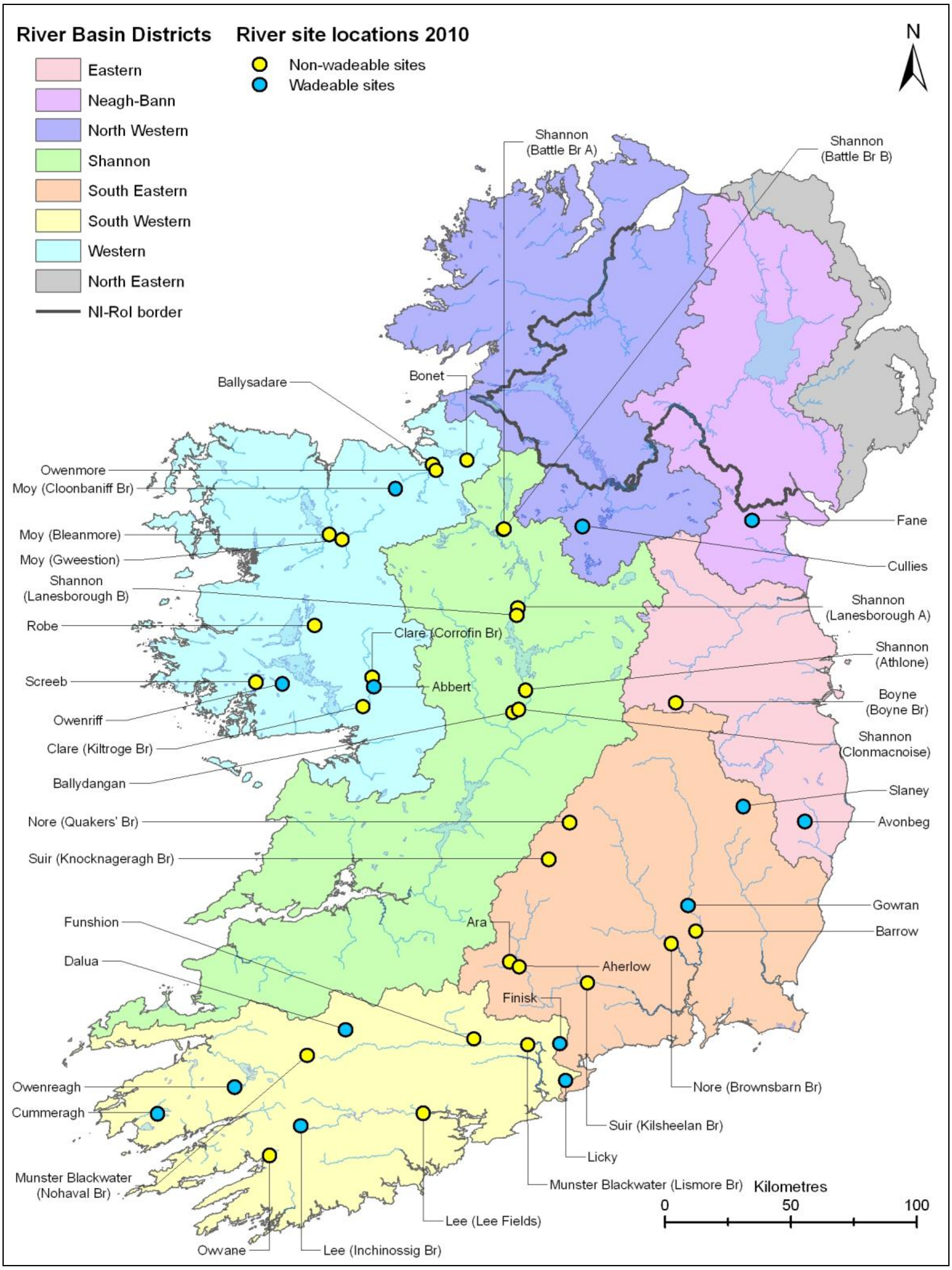

Fig. 2.2. Location of the 43 river sites surveyed for the WFD fish surveillance monitoring programme, May to August 2010

2.3 Transitional waters

Twenty-five transitional water bodies, ranging in size from 0.12km^2 (Drongawn Lough, SWRBD) to 28.21km^2 (Barrow Suir Nore Estuary, SERBD), were surveyed between September and October 2010 (Table 2.4 and Fig. 2.3).

Water bodies were distributed throughout four RBDs; seven water bodies were surveyed in the ERBD, ranging in size from 0.18km^2 (Avoca Estuary, Co. Wicklow) to 4.81km^2 (Lower Liffey Estuary, Co. Dublin). Eight water bodies were surveyed in the SERBD, ranging in size from 0.64km^2 (Upper Barrow Nore Estuary) to 28.21km^2 (Barrow Suir Nore Estuary). Nine water bodies were surveyed in the SWRBD. Of these, seven were located in the Greater Cork Harbour area and two were located in Co. Kerry. One water body (Lough Gill) was surveyed in the SHIRBD.

Table 2.4.Transitional water bodies surveyed for the WFD fish surveillance monitoring programme, September to October 2010 (FT=freshwater tidal, TW=transitional and L=lagoon)

Water body	MS Code	Easting	Northing	Type	Area (km^2)
ERBD					
Avoca Estuary	EA_150_0100	324953	173295	TW	0.18
Broad Lough	EA_130_0100	330594	195959	TW	0.80
Broadmeadow Water	EA_060_0100	320835	247207	L	3.34
Liffey Estuary, Lower	EA_090_0300	322144	234429	TW	4.81
Liffey Estuary, Upper	EA_090_0400	314071	234314	TW	0.20
Rogerstown Estuary	EA_050_0100	322928	252252	TW	3.05
Tolka Estuary	EA_090_0200	321433	236068	TW	3.58
SHIRBD					
Gill, Lough	SH_040_0100	60525	113990	L	1.40
SERBD					
Barrow Estuary, Upper	SE_100_0300	273066	137640	TW	1.15
Barrow Nore Estuary, Upper	SE_100_0250	272129	128644	TW	0.64
Barrow Suir Nore Estuary	SE_100_0100	271527	107512	TW	28.21
New Ross Port	SE_100_0200	267862	117105	TW	6.711
Nore Estuary	SE_100_0400	265312	135294	TW	1.26
Suir Estuary, Lower	SE_100_0500	266073	112602	TW	4.32
Suir Estuary, Middle	SE_100_0550	249824	114070	TW	7.03
Suir Estuary, Upper	SE_100_0600	243887	121066	FT	1.09
SWRBD					
Drongawn Lough	SW_190_0500	73056	64019	L	0.12
Glashaboy Estuary	SW_060_0800	172449	73470	TW	0.12
Kenmare River, Inner	SW_190_0300	90195	69837	TW	3.79
Lee (Cork) Estuary, Lower	SW_060_0900	172082	72051	TW	0.89
Lee (Cork) Estuary, Upper	SW_060_0950	165903	71693	TW	0.25
Mahon, Lough	SW_060_0750	177107	69092	TW	12.23
Mahon, Lough (Harper's Island)	SW_060_0700	180271	72382	TW	2.05
North Channel Great Island	SW_060_0300	183669	69611	TW	7.96
Owenacurra Estuary	SW_060_0400	188010	71718	TW	1.12

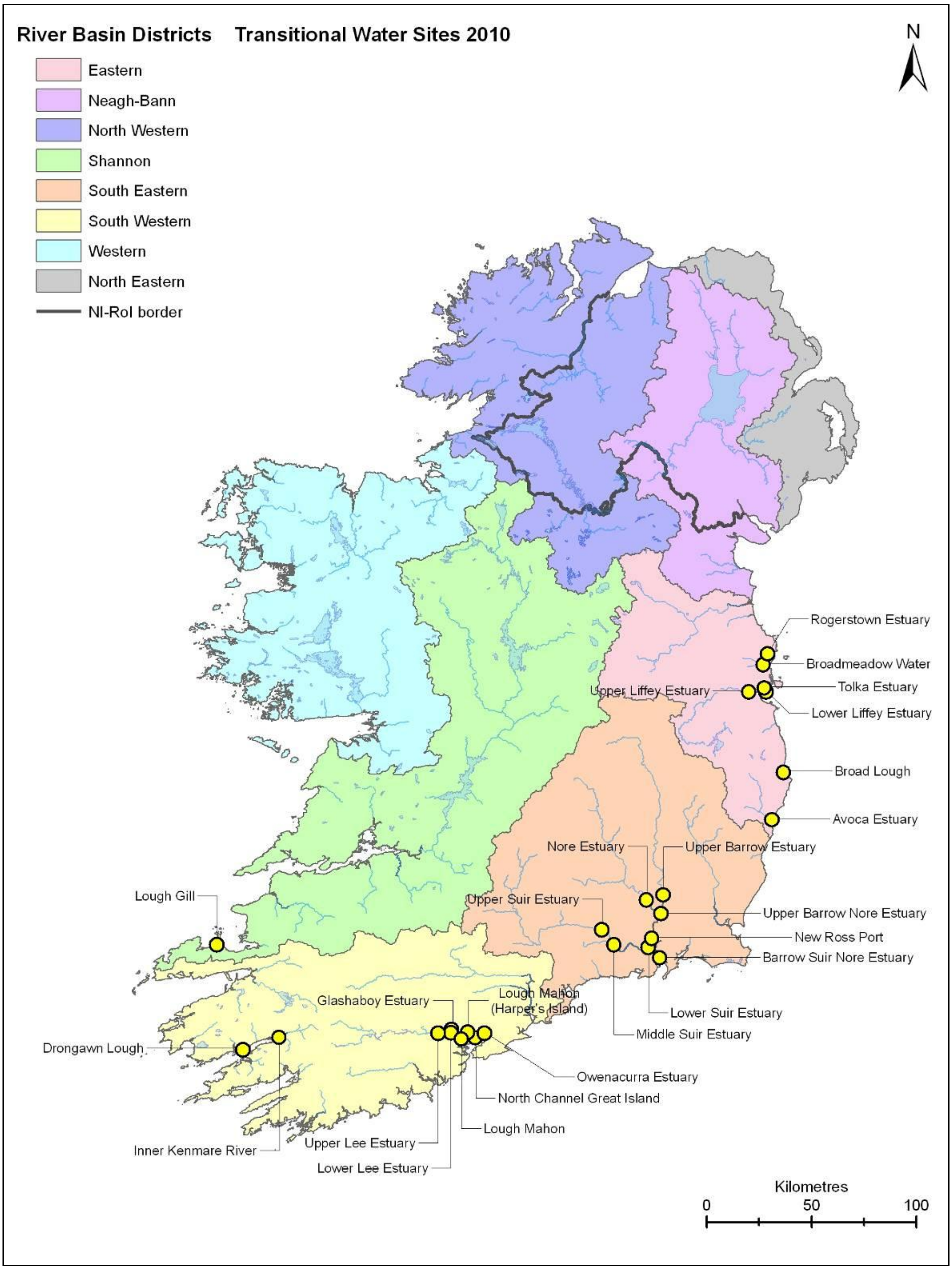

Fig. 2.3. Location of the 25 transitional water bodies surveyed for the WFD fish surveillance monitoring programme, September to October 2010

3. METHODS

All surveys were conducted using a suite of European standard methods (CEN, 2003; CEN, 2005a; CEN, 2005b). Electric fishing is the main survey method used in rivers and a multi-method netting approach is used in lakes and transitional waters. Details of these methods are outlined below.

3.1 Lakes

3.1.1 Survey methodology

Lake water bodies were surveyed using a netting method developed and tested during the NSSHARE Fish in Lakes Project in 2005 and 2006 (Kelly *et al*., 2007b and 2008a). The method is based on the European CEN standard for sampling fish with multi-mesh gill nets (CEN, 2005b); however, the netting effort has been reduced (approx 50%) for Irish lakes in order to minimise damage to fish stocks.

Monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets (Plate 3.1) were used to survey the fish populations in lakes using a stratified random sampling design. Each lake was divided into depth strata (0-2.9m, 3-5.9m, 6-11.9m, 12-19.9m, 20-34.9m, 35-49.9m, 50-75m, >75m) and random sampling was then conducted within each depth stratum (CEN, 2005b).Surface floating survey gill nets (Plate 3.2), fyke nets (one unit comprised of 3 fyke nets; leader size 8m x 0.5m, Plate 3.3) and benthic braided single panel (62.5mm mesh knot to knot) survey gill nets were also used to supplement the CEN standard gill netting effort.

Survey locations were randomly selected using a grid placed over a map of the lake. 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 randomised. Nets were set over night, and all lake surveys were completed between June and early October.

3.1.2 Processing of fish

All fish were counted, measured and weighed on site. Scales were removed from salmonids, roach, rudd, tench, pike and bream. Samples of some fish species were returned to the laboratory for further analysis, e.g. age analysis using char/eel otoliths and perch opercular bones. Stomach contents and sex were determined for any fish retained.

3.1.3 Water chemistry

Conductivity, pH, temperature and dissolved oxygen depth profiles were measured on site using a multiprobe. A Secchi disc was used to measure water clarity.

Plate 3.1. Processing fish from a gill net on New Lake, Co. Donegal

Plate 3.2. Setting a surface floating monofilament multi-mesh CEN standard survey gill net on Lough Erne, Co. Fermanagh

Plate 3.3. Sorting fyke nets on Lough Anure, Co. Donegal

3.2 Rivers

Electric fishing is the method of choice to obtain a representative sample of the fish assemblage in river sites. A standard methodology was developed by the Central Fisheries Board for the WFD fish surveillance monitoring programme (CFB, 2008a), in compliance with the European CEN standard for fish stock assessment in wadeable rivers (CEN, 2003). Environmental and abiotic variables are also measured on site. A macrophyte survey was also carried out at selected wadeable sites. Surveys were conducted between May and August (to facilitate the capture of 0+ salmonids) when stream and river flows were moderate to low.

3.2.1 Survey methodology

Each site was sampled by depletion electric fishing (where possible) involving one or more anodes, depending on the width of the site. Sampling areas were isolated using stop nets, or where this was not practicable, regions clearly delineated by instream hydraulic or physical breakpoints, such as well defined shallow riffles or weirs were utilised. Where possible, three electric fishing passes were conducted at each site.

In small wadeable channels (<0.5-0.7m in depth), portable landing nets (anode) connected to control boxes and portable generators (bank-based) or electric fishing backpacks were used to sample in an upstream direction (Plate 3.4a). In larger, deeper channels (>0.5-1.5m), fishing was carried out from a flat-bottomed boat(s) in a downstream direction using a generator, control box and a pair of electrodes (Plate 3.4b). A representative sample of all habitats was sampled (i.e. riffle, glide, pool).

Plate 3.4. Electric fishing with bank-based generators (a) in the River Gourna (2008) and boat-based generators (b) on the Owvane River (2010)

Fish from each pass were sorted and processed separately. Length and weight of all fish captured were measured and scales were removed from a subsample of fish for age analysis (Plate 3.5). All fish were held in a large bin of oxygenated water after processing until they were fully recovered before being returned to the river. Samples of eels were returned to the laboratory for further analysis (e.g. age, stomach contents and sex).

For various reasons, including river width and the practicalities of using stop-nets, three electric fishing passes were not possible or practical at all sites. Therefore, in order to draw comparisons between sites, fish densities were calculated using data from the first electric fishing pass only.

Plate 3.5. Processing fish for length, weight and scale samples

3.2.2 Habitat assessment

An evaluation of habitat quality is critical to any assessment of ecological integrity and a habitat assessment was performed at each site surveyed. Physical characterisation of a stream includes documentation of general land use, description of the stream origin and type, summary of riparian vegetation and measurements of instream parameters such as width, depth, flow and substrate (Barbour *et al*., 1999).

At each site, the percentage of overhead shade, percentage substrate type and instream cover were visually assessed. Wetted width was measured at three transects and depth was measured at five intervals along the reach fished. The percentage of riffle, glide and pool was estimated in each reach surveyed. Conductivity was also recorded at each site. A summary of environmental and abiotic variables recorded, showing the range amongst all river sites surveyed, is shown in Table 3.1.

Table 3.1.Environmental and abiotic variables recorded for all river sites

Environmental / abiotic variable	Min	Max	Mean	Footnote
River reach sampled				
Length fished (m)	44	732	246	1
Mean depth (m)	0.12	6.00	0.96	2
Max depth (m)	0.20	6.00	1.44	3
Wetted width (m)	3.50	95.40	24.33	4
Surface area (m2)	214.50	45628.00	9250.99	5
Shade	0	3	-	6
Instream cover	0	80	18	7
Bank slippage	0	1	-	8
Bank erosion	0	1	-	8
Fencing (RHS & LHS)	0	1	-	8
Trampling (RHS & LHS)	0	1	-	8
Water level	1	3	-	9
Velocity	1	3	-	10
Conductivity	43.1	731.0	319.6	
Flow type (%)				
Riffle	0	80	18.06	7
Glide	15	100	73.88	7
Pool	0	50	8.04	7
Substrate type (%)				
Bedrock	0	30	1.40	7
Boulder	0	35	7.56	7
Cobble	0	94	37.09	7
Gravel	0	90	27.77	7
Sand	0	80	10.70	7
Mud_silt	0	100	15.49	7

***Footnotes*:**

1. Measured over length of site fished
2. Mean of 30 depths taken at 6 transects through the site
3. Measured at deepest point in stretch fished
4. Mean of 6 widths taken at 6 transects
5. Calculated from length and width data
6. Shade due to tree cover, estimated visually at the time of sampling (0-none, 1-light, 2-medium, 3-heavy)
7. Percentage value, estimated visually at the time of sampling
8. Bank slippage, bank erosion, fencing estimated visually at time of sampling (presence or absence recorded as 1 or 0)
9. Water level, estimated visually at time of sampling-3 grades (1-low, 2-normal & 3-flood)
10. Velocity rating, estimated visually at time of sampling-5 ratings given (1-very slow, 2-slow, 3-moderate, 4-fast, 5-torrential)

3.3 Transitional waters

Transitional waters (estuaries/lagoons) are an interface habitat, where freshwater flows from rivers and mixes with the tide and salinity of the sea. As such, they provide a challenging habitat to survey due to their constantly changing environmental conditions. In every 24 hour period, the tidal level rises and falls twice, subjecting extensive areas to inundation and exposure.

3.3.1 Survey methodology

Current work in the UK indicates the need for a multi-method approach, using various netting techniques, to sampling for fish in estuaries. These procedures have been adopted by Inland Fisheries Ireland as the standard method for sampling fish in transitional waters in Ireland for the WFD monitoring programme (CFB, 2008b). Sampling methods include:

- Beach seining using a 30m fine-mesh net to capture fish in littoral areas
- Beam trawling for specified distances (100–200m) in open water areas adjacent to beach seining locations
- Fyke nets set overnight in selected areas adjacent to beach seining locations

3.3.1.1 Beach Seining

Beach seining is conducted using a four-person team; two staff on shore and two in a boat. Sampling stations are selected to represent the range of habitat types within the site, based on such factors as exposure/orientation, shoreline slope and bed type. The logistics of safe access to shore and feasibility of unimpeded use of the seine net are also considered.

The standard seine net used in transitional water surveys is 30m in length and 3m deep, with 30m guide ropes attached to each end. Mesh size is 10mm. The bottom, or lead line, has lead weights attached to the net in order to keep the lead line in contact with the sea bed. This increases sediment disturbance and catch efficiency.

All beach seine nets were set from a boat (Plate 3.6), with one end or guide rope held on shore while the boat followed an arc until the netwas fully deployed. In conditions with minimal influence of tide or flow, the seine nets were allowed to settle while the second guide rope was brought to shore. The net was then drawn into a position where it lay parallel to the shore before being slowly drawn shoreward (Plate 3.7).

Plate 3.6. Beach seining: deploying the net from a boat

Plate 3.7. Beach seining: hauling the net towards shore by hand

3.3.1.2 Fyke netting

Fyke nets, identical to those used for lake surveys (one unit comprised of 3 fyke nets; leader size 8m x 0.5m, Plate 3.8), are the standard fyke nets used to sample fish in transitional waters. Each fyke net unit is weighted by two anchors to prevent drifting and a marker buoy is attached to each end.

Nets were deployed overnight to maximise fishing time in different types of habitats, i.e. rocky, sandy and weedy shores. Tide is also a factor when deploying the fyke nets as they must be submerged at all times to fish effectively.

Plate 3.8. Fyke net being hauled aboard a rigid inflatable boat (RIB)

3.3.1.3 Beam trawl

Beam trawling enables sampling of littoral and open water habitats where the bed type is suitable. The beam trawl used for WFD fish sampling within IFI measures 1.5m x 0.5m in diameter, with a 10mm mesh bag, decreasing to 5mm mesh in the cod end (Plate 3.9). A 1.5m metal beam ensures the net stays open while towing, with small floats on the top line and 3m of light chain on the bottom line. A 1m bridle is attached to a 20m tow rope and the net is towed by a 3.8m RIB.

Trawls were conducted over transects of 200m in length with the start and finish recorded on a handheld GPS. Trawling must be done over a sand or gravel substrate, as trawling over soft sediments can cause the net to foul with mud and make the recovery of the trawl extremely difficult. After each trawl the net was hauled aboard and the fish were processed.

Plate 3.9. Beam trawl used for transitional water surveys

3.3.2 Processing of fish

At the completion of each seine net haul, fyke net (overnight setting) and beam trawl transect the fish were carefully removed from the nets and placed into clean water. One field team member examined each fish whilst the other recorded date set, time set, date out, estuary name, grid reference, net information (type), number of each species and lengths. Once processing was complete the majority of fish were returned to the water alive. Representative sub-samples of a number of abundant fish species were measured (fork length) to the nearest millimetre. Any fish species that could not be identified on site was preserved in ethanol or frozen and taken back to the IFI laboratory for identification.

3.3.3 Additional information

Information on bed type and site slope was recorded by visual assessment at each beach seine sample station, based on the dominant bed material and slope in the wetted area sampled. Three principal bed types were identified (gravel, sand and mud). Shoreline slopes were categorized into three groups: gentle, moderate and steep. Salinity and water temperature were also recorded at all beach seine sampling stations. A handheld GPS was used to mark the precise location of each sampling station.

3.4 Ageing of fish

A subsample of the dominant fish species from rivers and lake surveys were aged (five fish from each 1cm class); fish scales were aged using a microfiche reader. Perch opercular bones were prepared for ageing by boiling, cleaning and drying and were aged using a binocular microscope/digital camera system with Image Pro Plus software (Plate 3.10). Char otoliths were cleared in 70% ethanol and aged using a binocular microscope (Plate 3.11). Eel otoliths were prepared for aging by the method of ‘cutting and burning’ and were subsequently aged using a binocular microscope/digital camera system with Image Pro Plus software (Plate 3.12). Back calculated lengths at age were determined in the laboratory.

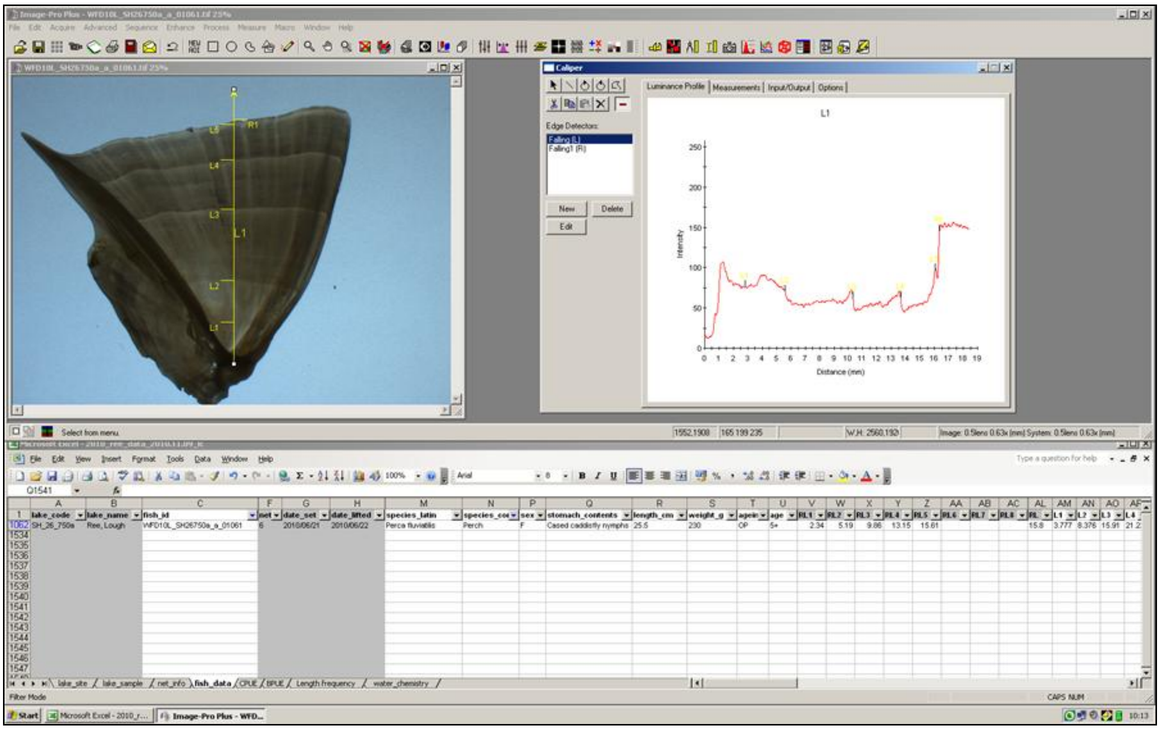

Plate 3.10. Opercular bone aging using binocular microscope/digital camera system with Image Pro Plus software (a 5+ perch from Lough Ree)

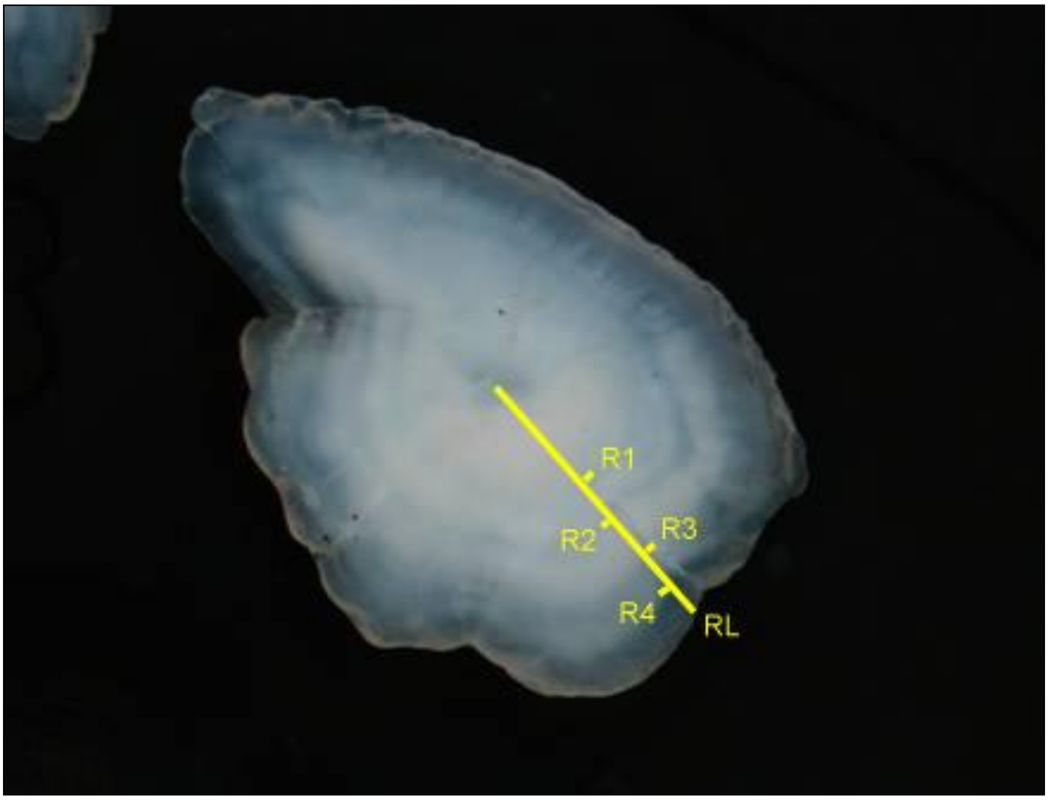

Plate 3.11. Char otolith (4+) from Kindrum Lough, Co. Donegal

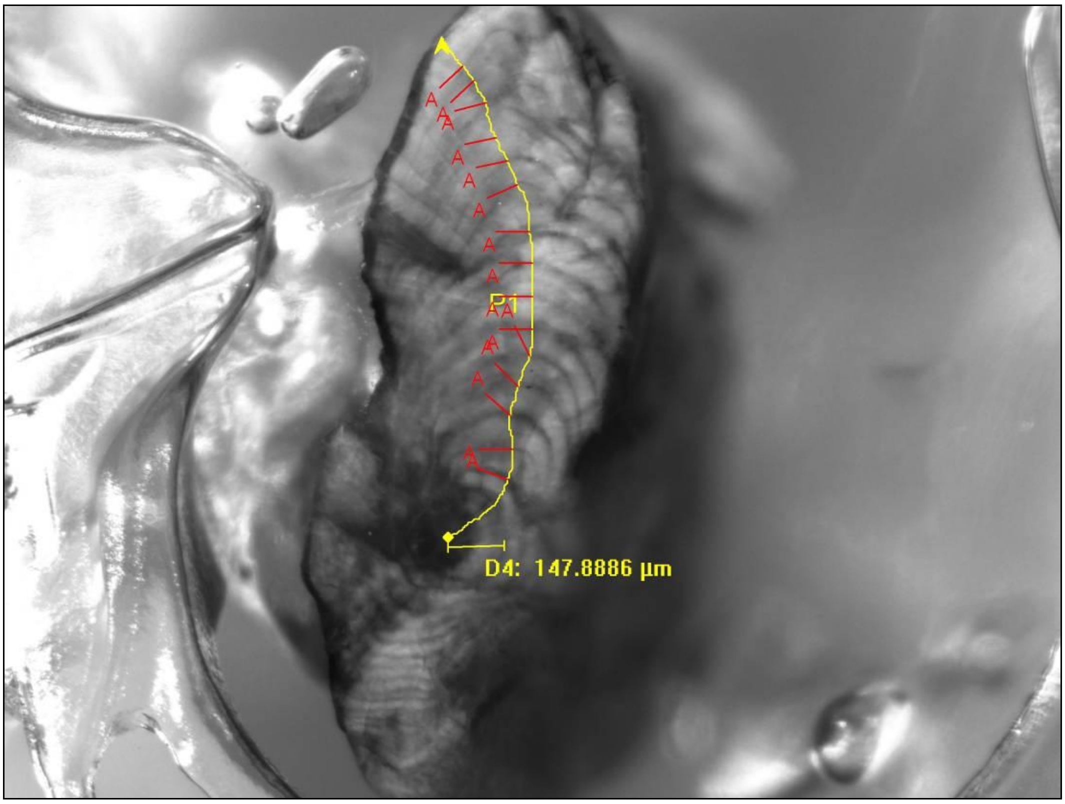

Plate 3.12. Eel otolith (15+) from Lough Cullin

3.5 Quality assurance

CEN (2005a) recommends that all activities undertaken during the standard fish sampling protocol (e.g. training of the lakes team, handling of equipment, handling of fish, fish identification, data analyses, and reporting) should be subjected to a quality assurance programme in order to produce consistent results of high quality. A number of quality control procedures have been implemented for the current project. All WFD staff have been trained in electric fishing techniques, fish identification, sampling methods (including gill netting, seine netting, fyke netting and beam trawling), fish aging, data analyses, off road driving and personal survival techniques.

There is a need for quality control for fish identification by field surveyors, particularly in relation to hybrids of coarse fish. Samples of each fish species (from the three water body types) were retained when the surveyor was in any doubt in relation to the identity of the species, e.g. rudd and/or roach hybrids. There is also a need for quality control when ageing fish; therefore every tenth scale or other ageing structure from each species was checked in the laboratory by a second biologist experienced in age analysis techniques.

Further quality control measures as they arise are continually being implemented each year in relation to standardising data analyses, database structure and reporting.

All classification tools for fish will continue to be developed during 2011 and outputs from these will be intercalibrated across Europe.

3.6 Biosecurity - disinfection and decontamination procedures

One of the main concerns when carrying out WFD surveillance monitoring is to consider the changes which may occur to the biota as a consequence of the unwanted spread of non-native species, such as the zebra mussel, from water body to water body. 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 during the "NS Share Fish in Lakes" project for disinfection of survey equipment (Kelly and Champ, 2006) and this is followed diligently by staff in the IFI WFD team when moving between water bodies (Plate 3.13).

Plate 3.13. Disinfection procedure on a boat being moved between water bodies

3.7 Hydroacoustic technology: new survey method development

3.7.1 What is hydroacoustic technology?

Hydroacoustics (or echo sounding) is the use of sound energy to remotely gather information from a water body by transmitting a pulse of sound into the water and assessing the position and strength of the returning echo. Most echo-sounders used for fisheries assessment operate in the range of 38 to 200KHz, with a higher frequency giving a finer resolution for target detection.

Two or more frequencies are generally used simultaneously to aid in discrimination between, for example, fish and zooplankton. Dual frequencies can also be used to simultaneously beam vertically and horizontally to assess the fish stocks on or near the surface as well as in deeper water. Modern scientific echo sounders utilise computers for both data recording in the field and subsequent post-processing of the recorded acoustic data. A GPS is also used to record positional data during the survey. Plate 3.14 below shows a typical echo sounder setup for use in freshwater hydroacoustic fish surveys.

Plate 3.14. Left: Hydroacoustic transducers mounted on a boat (front - horizontally beaming, rear - vertical beaming). Transducers are lifted out of the water for illustrative purposes. Right: Laptop computer controlling the transducers via General Purpose Transeivers (GPT).

3.7.2 Applications of hydroacoustics in freshwater fish stock assessment

Hydroacoustic surveys have become a very useful tool in freshwater fish stock assessment, providing invaluable information on fish abundance, size distribution, spatial distribution and behaviour, whilst limiting the destructive use of gill nets. Transducers can be oriented both vertically and horizontally, enabling observations to be made on different fish communities inhabiting different areas within a water body.

Vertical hydroacoustic surveys are most useful in deep lakes, mainly due to the narrow cross section of the acoustic beam and a resultant limited degree of coverage in shallow water situations. One of the most valuable uses for vertical hydroacoustic surveys in lakes is the targeted approach of assessing populations of indicator species or species at risk, such as char or pollan (Plate 3.15), which tend to inhabit the deeper areas. Hydroacoustics can be used very effectively to locate areas where shoals of deep water fish are present and targeted ground-truth netting can then be used for species confirmation. Abundance estimates can subsequently be calculated from the acoustic data. Furthermore, the spatial distribution and size distribution of species of interest can also be assessed. These methods have recently been used, for example, to confirm the presence of a new population of pollan in Lough Allen (Harrison *et al*., 2010). During the 2010 WFD fish monitoring programme, the same methods were used to assess the current status of pollan in Lough Ree (Harrison *et al*., in prep.). An example of an echogram showing a pollan shoal in Lough Ree is shown in Figure 3.16. The maximum water depth is approximately 30m, with a distinct shoal of pollan between 18 and 25m.

Plate 3.15. Pollan captured in Lough Ree during 2010

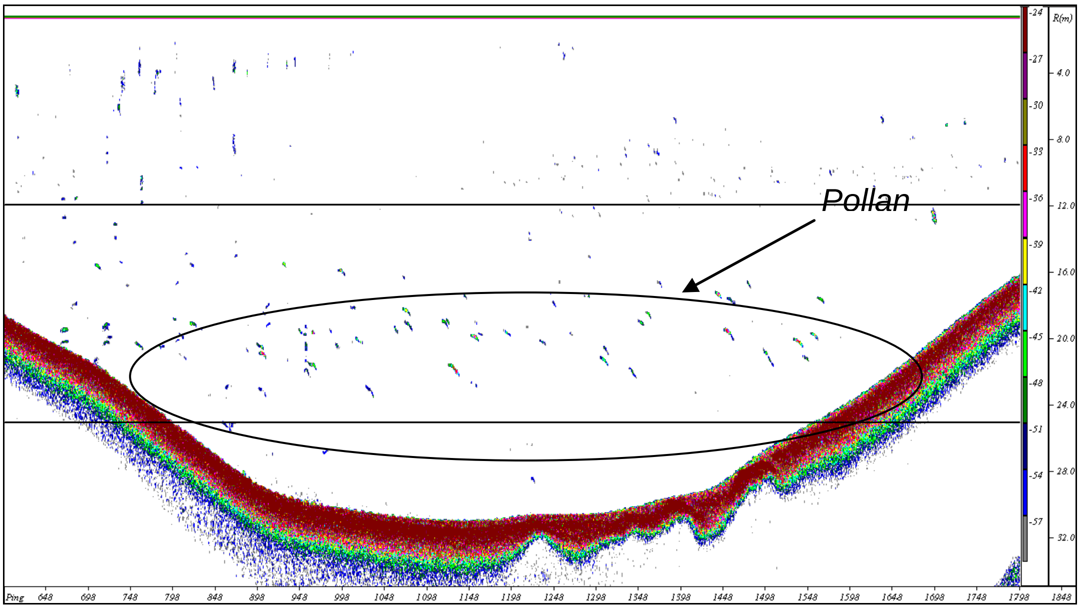

Fig. 3.16. Example of an echogram showing a pollan shoal from Lough Ree during post-processing

3.7.3 Future work

Further development in both hydroacoustic technology and survey methodology will see hydroacoustics play an increasing role in future WFD monitoring within IFI. Ongoing cooperation with other Member States in developing the CEN standard will help to progress this work. Hydroacoustic technology will also continue to be used to support other important work within IFI, including working with the Habitats Directive team in assessing the population status of priority species such as pollan, shad and Arctic char.

4. RESULTS

4.1 Lakes

4.1.1 Fish species composition and species richness

The native fish community of Irish lakes, in the absence of anthropogenic influence, is one dominated by salmonids, including at some sites the glacial relicts Arctic char (*Salvelinus alpinus*), pollan (*Coregonus autumnalis*) and Killarney shad (*Alosa fallax Killarnensis*). Three fish groups have been identified and agreed for Ecoregion 17 (Ireland) by a panel of fishery experts (Kelly *at al*., 2008b). These are Group 1 – native species, Group 2 – non-native species influencing ecology and Group 3 – non-native species generally not influencing ecology. In the absence of major human disturbance, a lake fish community is considered to be in reference state (in relation to fish) if the population is dominated by salmonids (or euryhaline species with an arctic marine past) (i.e. Group 1 - native species are the only species present in the lake). A list of fish species recorded, along with the percentage occurrence in the 25 lakes surveyed during 2010 is shown in Table 4.1and Figure 4.1.

Table 4.1. List of fish species recorded in the 25 lakes surveyed during 2010

	Scientific name	Common name	Number of lakes	% of lakes
	NATIVE SPECIES			
1	*Anguilla anguilla*	Eel	22	88
2	*Salmo trutta*	Brown trout	20	80
3	*Gasterosteus aculeatus*	Three-spined stickleback	8	33
4	*Salmo trutta*	Sea trout*	4	16
5	*Salvelinus alpinus*	Char	4	16
6		Adult salmon	3	12
6	*Salmo salar*	Juvenile salmon	2	8
7	*Pungitius pungitius*	Nine-spined stickleback	2	8
8	*Coregonus autumnalis*	Pollan	1	4
9	*Platichthys flesus*	Flounder	1	4
	NON NATIVE SPECIES (influencing ecology)			
10	*Perca fluviatilis*	Perch	17	68
11	*Esox lucius*	Pike	11	44
12	*Rutilus rutilus*	Roach	9	36
13	*Abramis brama*	Bream	6	24
14	*Phoxinus phoxinus*	Minnow	5	20
15	*Oncorhynchus mykiss*	Rainbow trout	3	12
	NON NATIVE SPECIES (generally not influencing ecology)			
16	*Scardinius erythropthalmus*	Rudd	7	28
17	*Tinca tinca*	Tench	3	12
	Hybrids			
	Rutilus rutilus x Abramis brama	Roach x bream hybrid	7	28

*Sea trout are included as a separate "variety" of trout

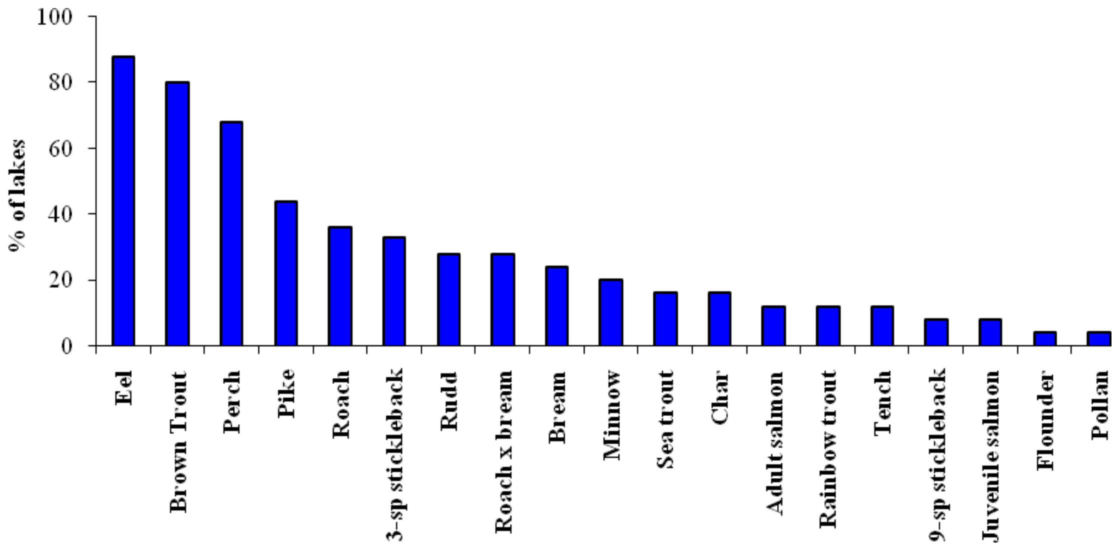

Fig. 4.1.Percentage of lakes surveyed for WFD fish surveillance monitoring during 2010 containing each fish species

A total of 17 fish species (sea trout are included as a separate "variety" of trout) and one type of hybrid were recorded (Table 4.1). Eel was the most common fish species, occurring in 88% of lakes surveyed, followed by brown trout (80%), perch (68%) and pike (44%) (Fig. 4.1).

Fish species richness (excluding hybrids) ranged from two species at one lake (Lough Nambrackmore) to a maximum of eight species at one lake (Lough Ree) (Table 4.2, Fig. 4.2). The highest number of native species (six species) was recorded in Glencar Lough. Native species (Group 1) were present in 24 of the 25 lakes surveyed (only Ross Lake contained no native species),Group 2 species were present in 22 lakes and Group 3 species were present in 10 lakes (Table 4.2).

Table 4.2. Fish species richness in the 25 lakes surveyed for WFD fish monitoring during 2010

Lake	Species richness	No. native species (Group 1)	No. non-native species (Group 2)	No. non-native species (Group 3)
Ree	8	3	4	1
Macnean Upper	7	2	4	1
Rea	7	4	2	1
Glencar	7	6	1	0
Lene	7	3	3	1
Erne Upper	6	2	4	0
Bane	6	3	3	0
Lattone	6	2	3	1
Macnean Lower	5	1	3	1
Glen	5	4	1	0
Beltra	5	4	1	0
Kylemore	5	4	1	0
Maumwee	5	4	1	0
Shindilla	5	4	1	0
Ardderry	5	4	1	0
Annagh/White	5	1	4	0
Urlaur	4	1	3	0
Aughrusbeg	4	3	0	1
Ross	4	0	4	0
Glenade	4	1	3	0
Atedaun	4	1	2	1
Lickeen	4	3	0	1
Lettercraffroe	4	3	1	0
Mushlin	3	1	1	1
Nambrackmore	2	2	0	0

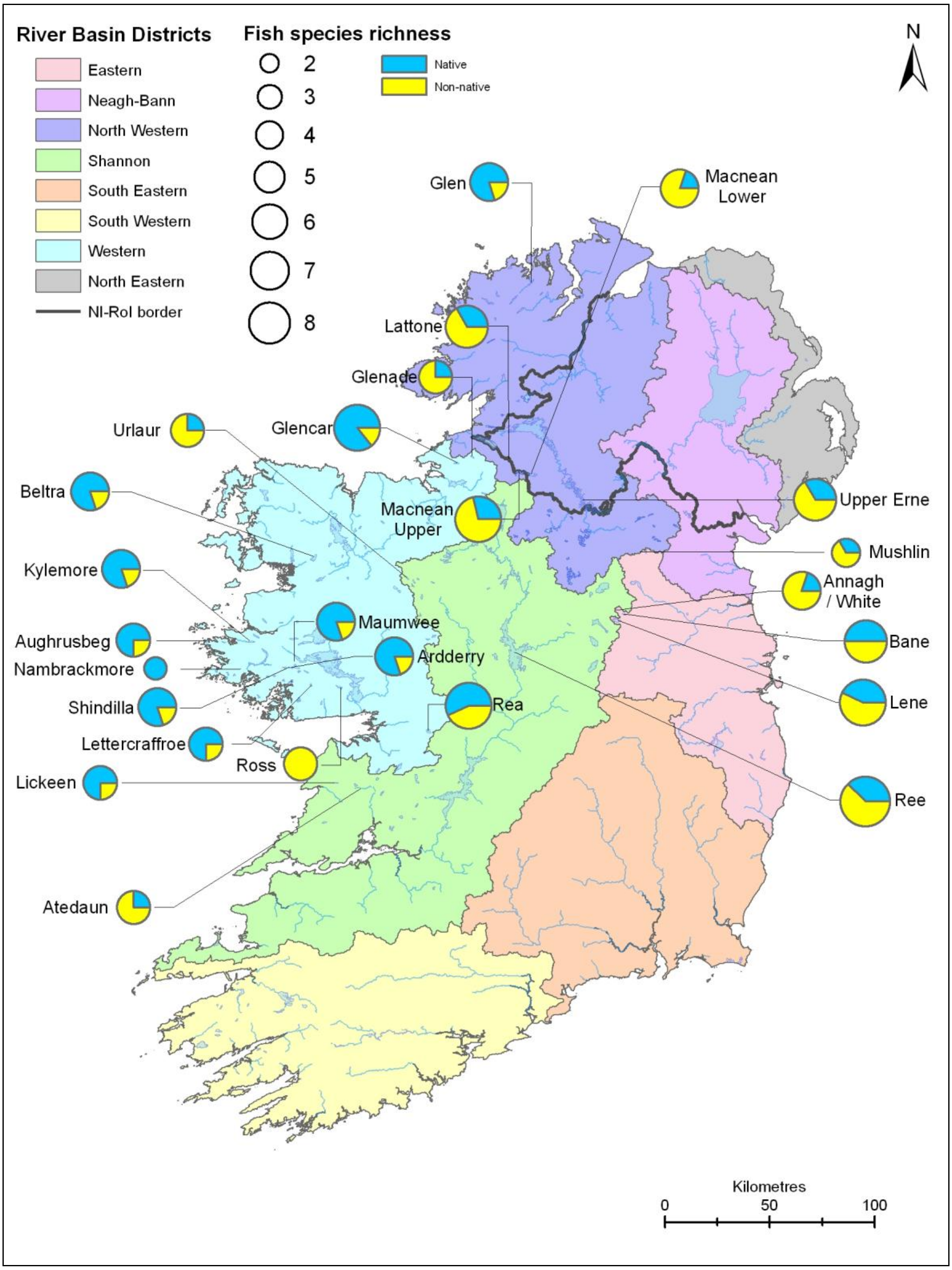

Fig 4.2 Fish species richness in the 25 lakes surveyed for WFD fish monitoring during 2010

4.1.2 Fish species distribution

Figures 4.3 to 4.15 show the distribution of each fish species amongst all lakes surveyed during 2010. The size of the circles indicates mean catch per unit effort (CPUE - mean number of fish per metre of net). Details of the presence/absence of each species in each lake are also given in Appendix 2.

Eels were widely distributed, being present in 22 out of the 25 lakes surveyed (Fig. 4.3). In general, salmonids were distributed towards the north and west of the country (Figs. 4.4 to 4.7). Sea trout were only captured in four lakes in the west (Beltra Lough, Kylemore Lough, Ardderry Lough and Glencar Lough) (Fig. 4.5). Juvenile salmon were only recorded in two lakes (Beltra Lough and Glen Lough) and adult salmon in three lakes (Beltra Lough, Maumwee Lough and Glencar Lough) (Fig. 4.6). Char were recorded in four lakes in the NWIRBD and WRBD (Glen Lough, Kylemore Lough, Shindilla Lough and Ardderry Lough) (Fig. 4.7). Pollan were recorded in one lake (Lough Ree).

Three-spined stickleback were also mainly restricted to the west of the country, being present in six lakes in the WRBD and two lakes in the ERBD and ShIRBD (Fig. 4.8).

The native Irish lake fish fauna has been augmented by the introduction of a large number of non-native species, introduced either deliberately, accidentally or through careless management, e.g. angling activities, aquaculture and the aquarium trade. Many non-native species have become established in the wild, the most widespread including pike, perch, roach, rudd and bream. The status of these species varies throughout Ireland, with much of the north-west and many areas in the west, south-west and east of Ireland still free from non-native species (Figs. 4.9 to 4.15).

Perch, followed by pike were the most widely distributed non-native species recorded during the 2010 surveillance monitoring programme, with perch (Fig. 4.9) being present in 17 lakes and pike (Fig. 4.10) being present in 11 of the 25 lakes surveyed. Roach were captured in nine lakes (four in the NWIRBD, three in the WRBD and two in the ShIRBD) (Fig. 4.11). Rudd were recorded in seven lakes (three lakes within the NWIRBD, two in the WRBD and two in the ShIRBD) (Fig. 4.12). Bream were recorded in six lakes, roach x bream hybrids were recorded in seven lakes and tench were recorded in three lakes (Figs. 4.13 to 4.15).

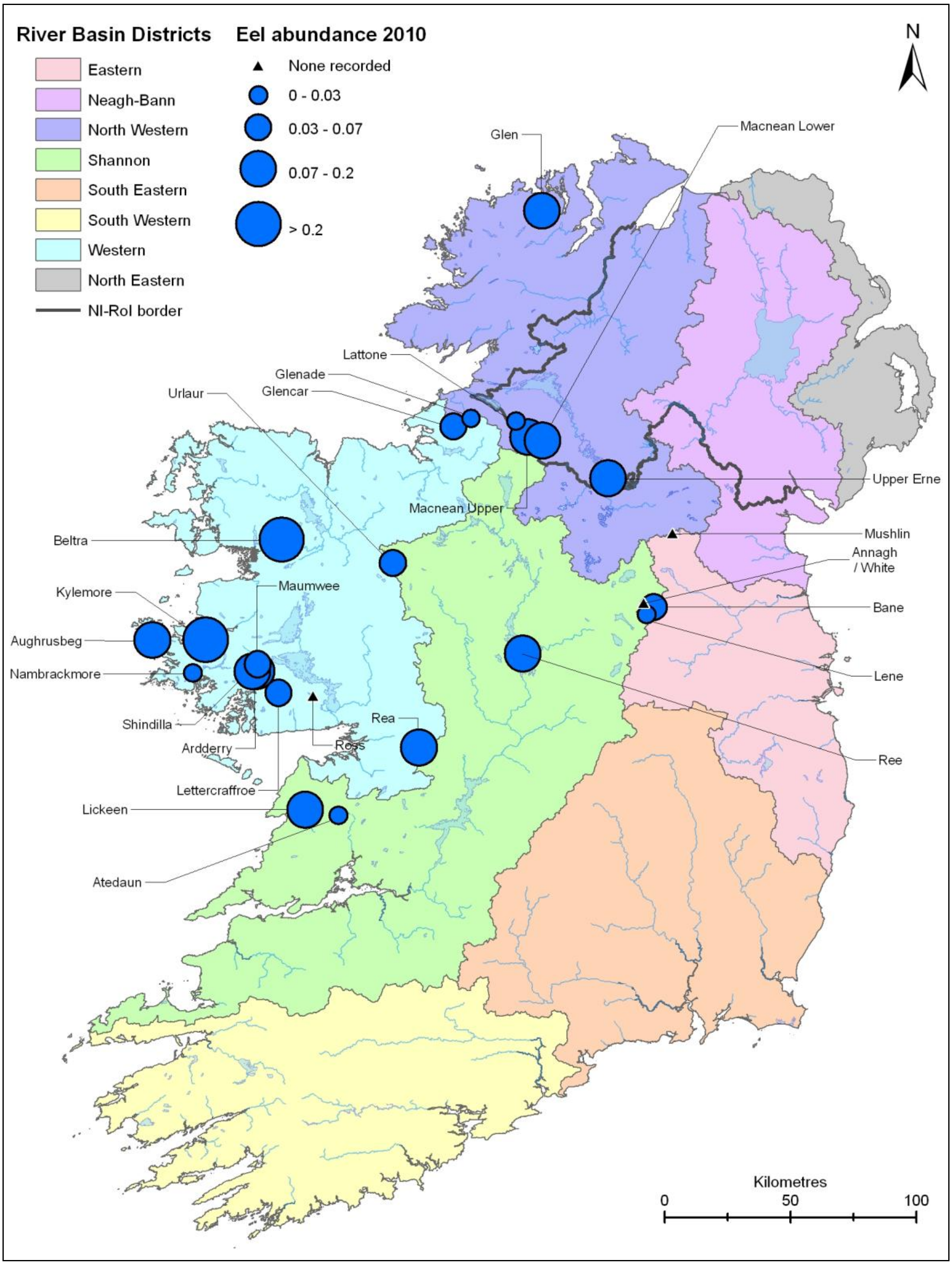

Fig. 4.3. Eel distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

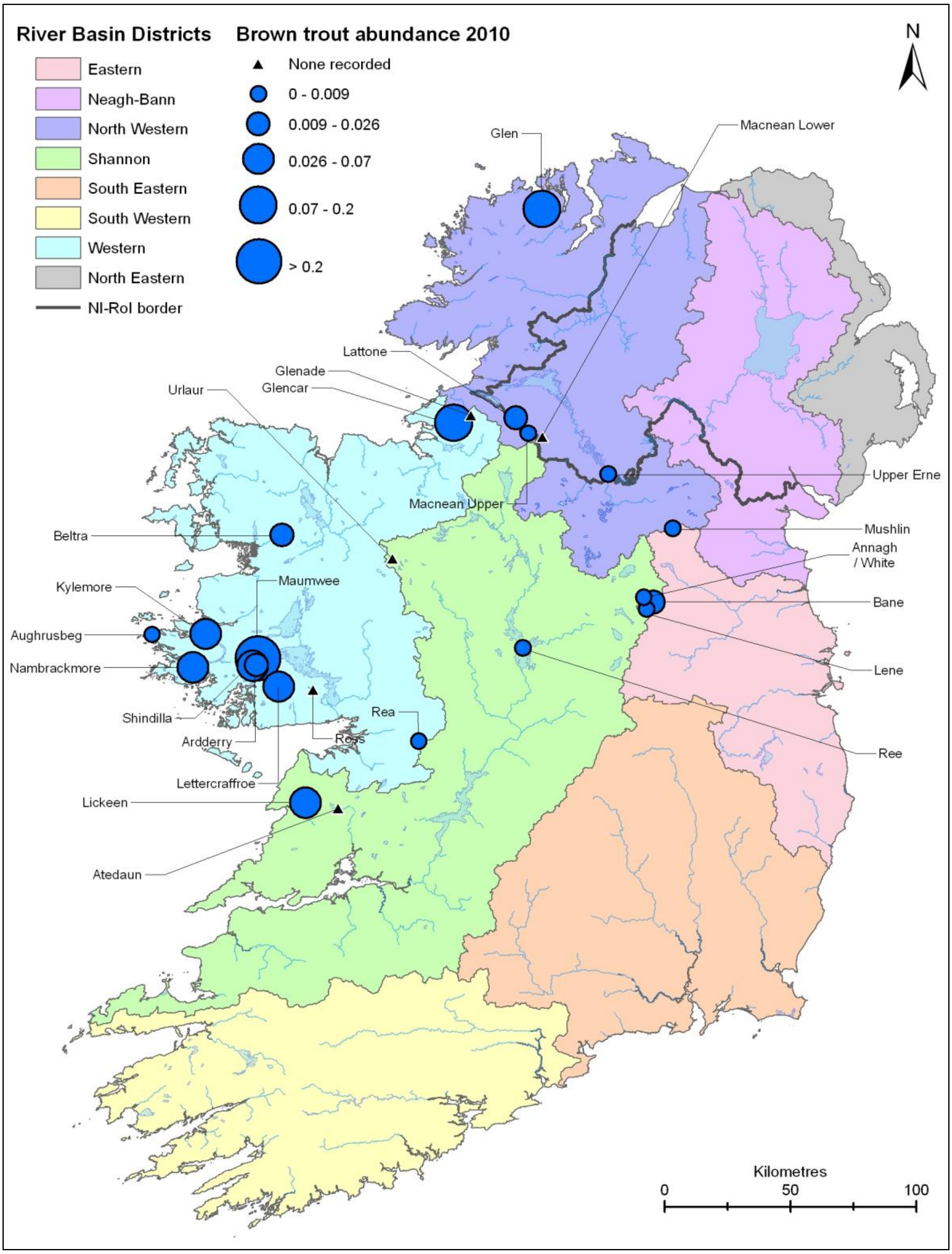

Fig. 4.4. Brown trout distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

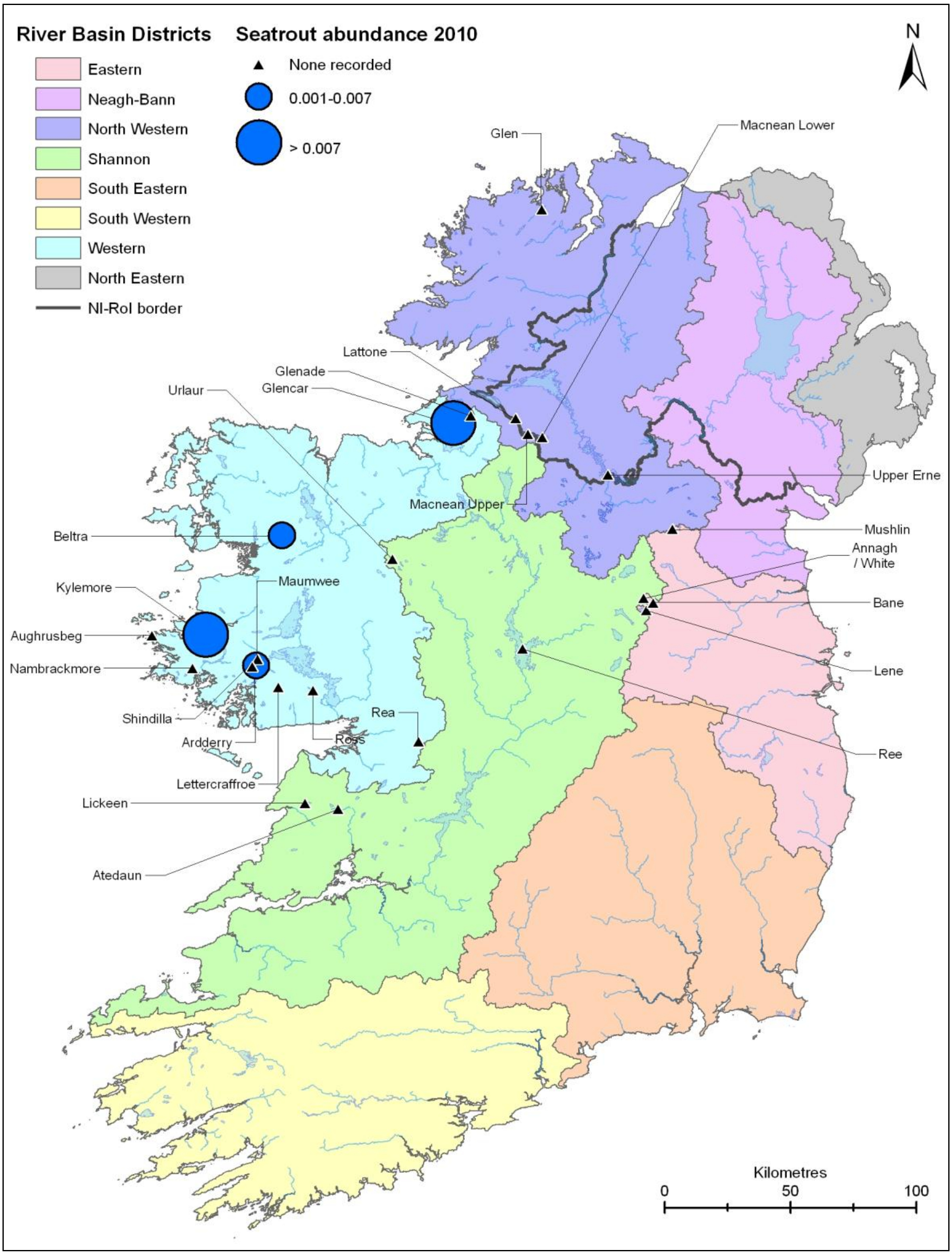

Fig. 4.5. Sea trout distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

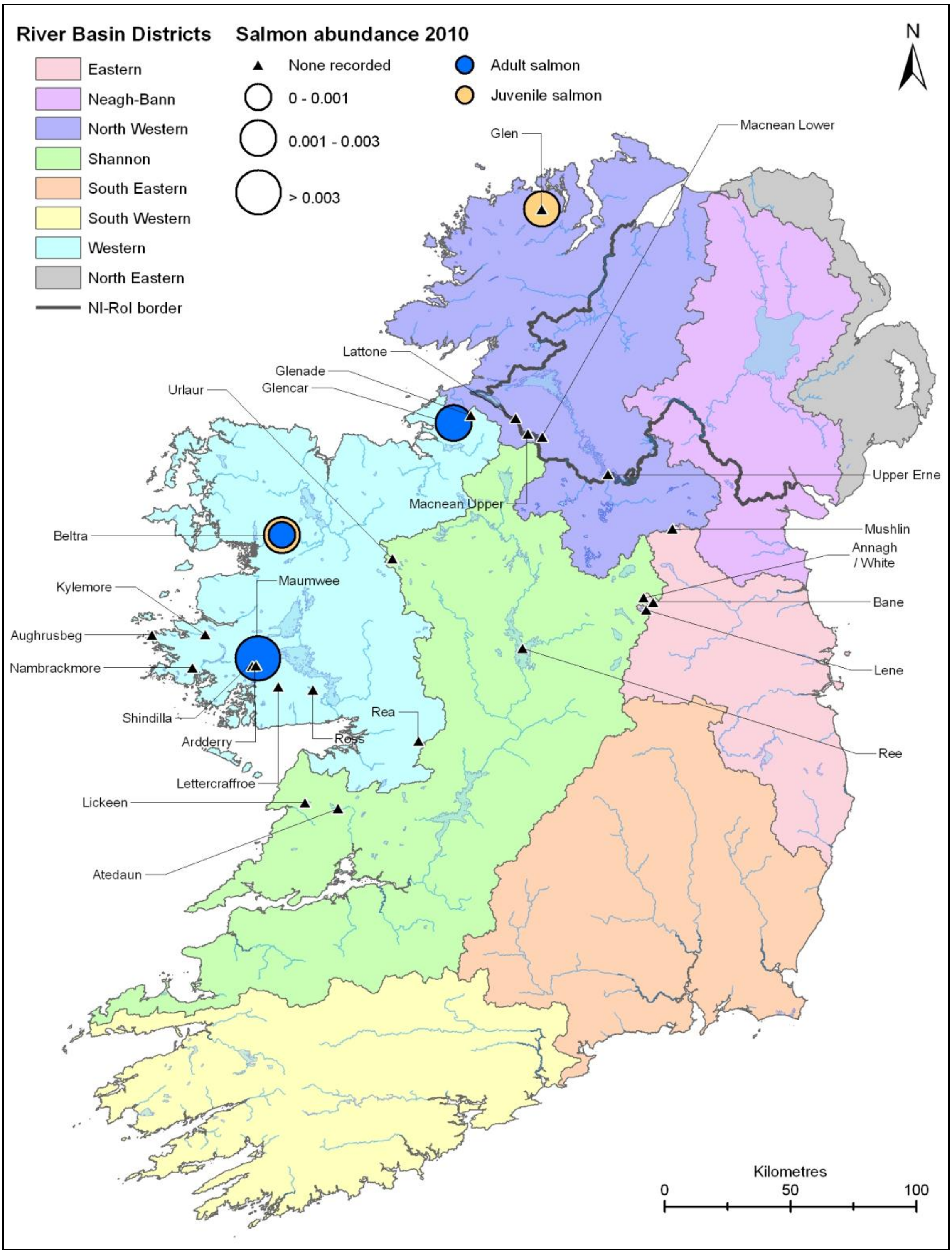

Fig. 4.6. Salmon distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

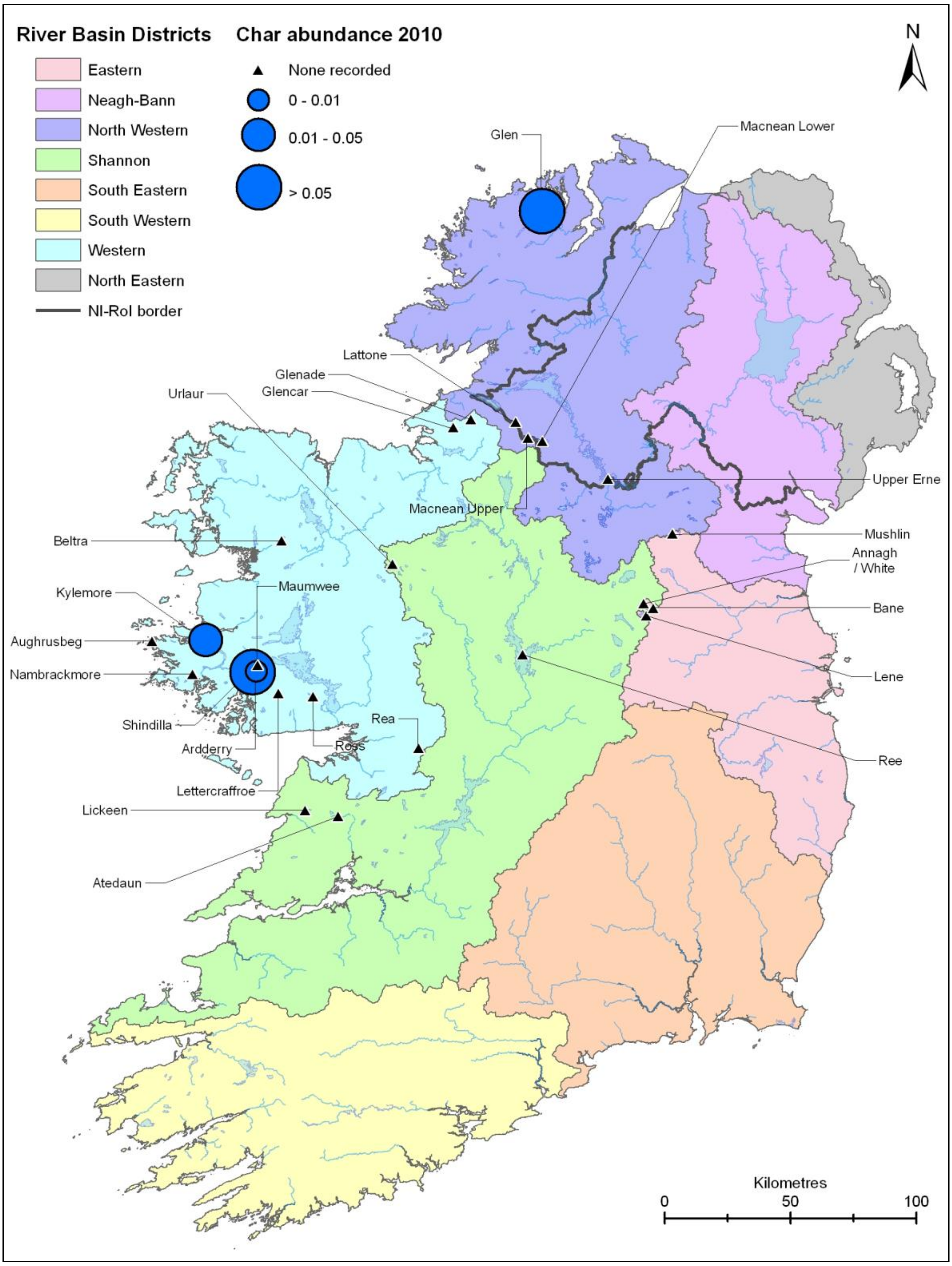

Fig. 4.7. Char distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

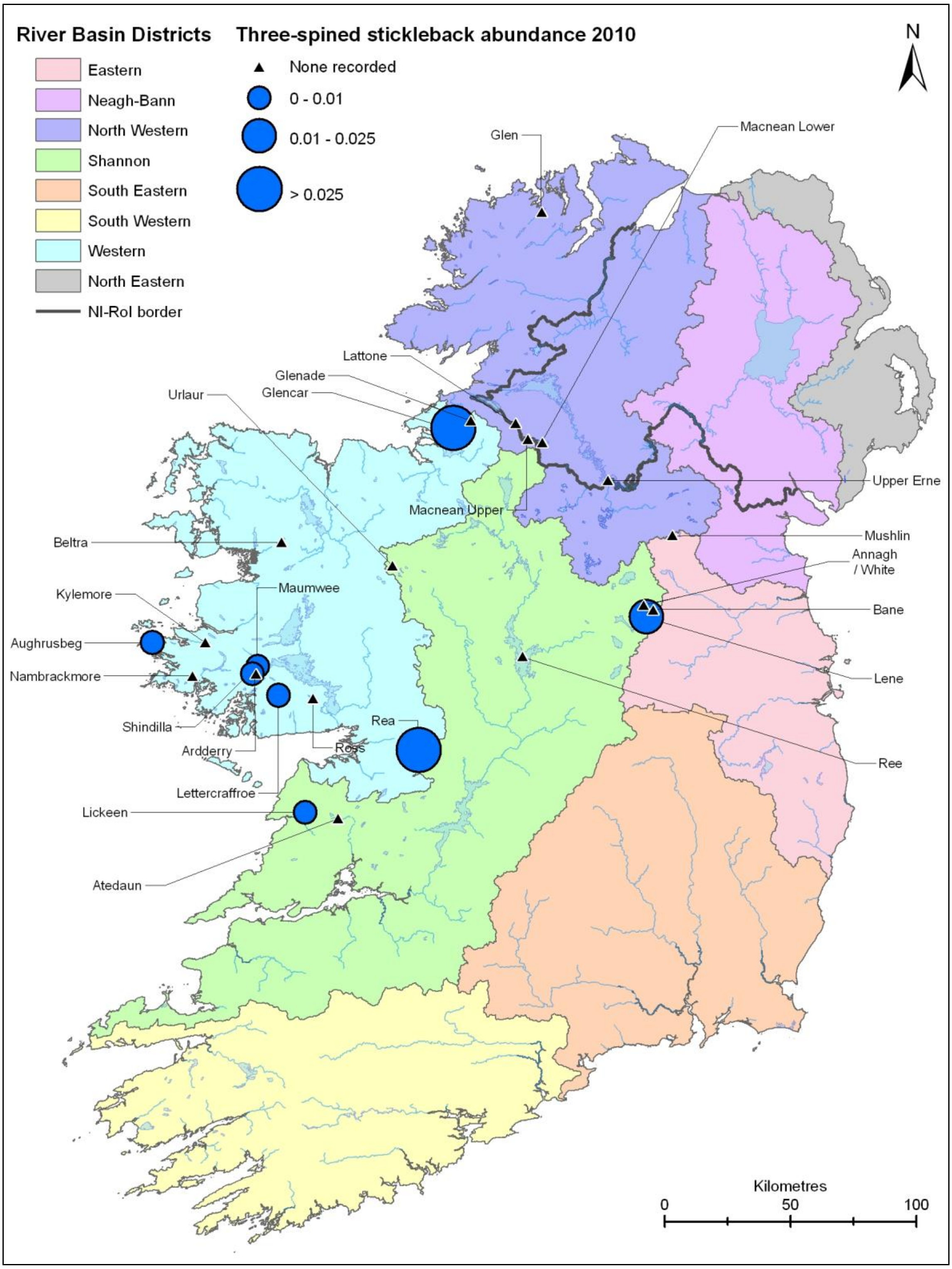

Fig. 4.8. 3-spined stickleback distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

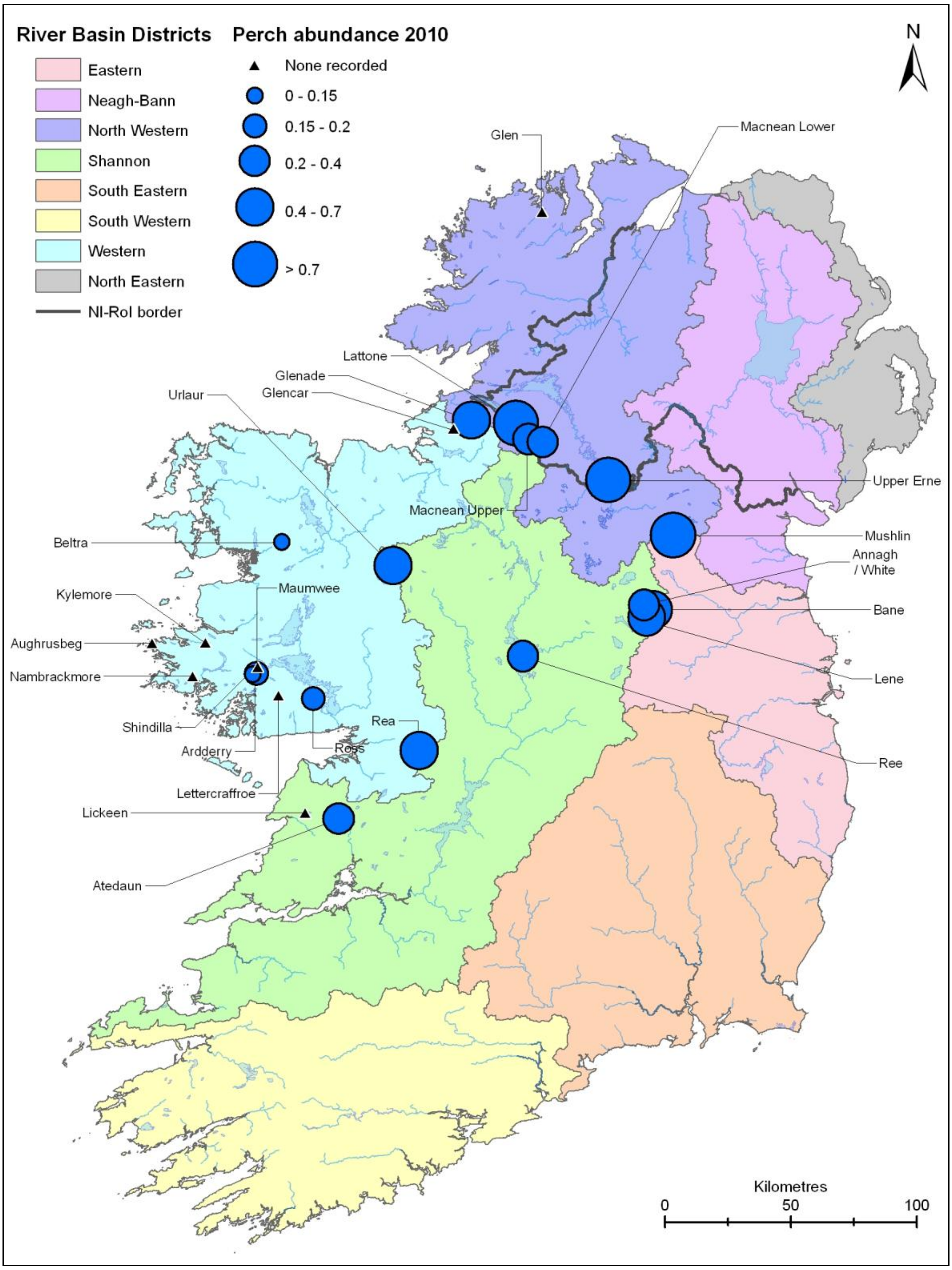

Fig. 4.9. Perch distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

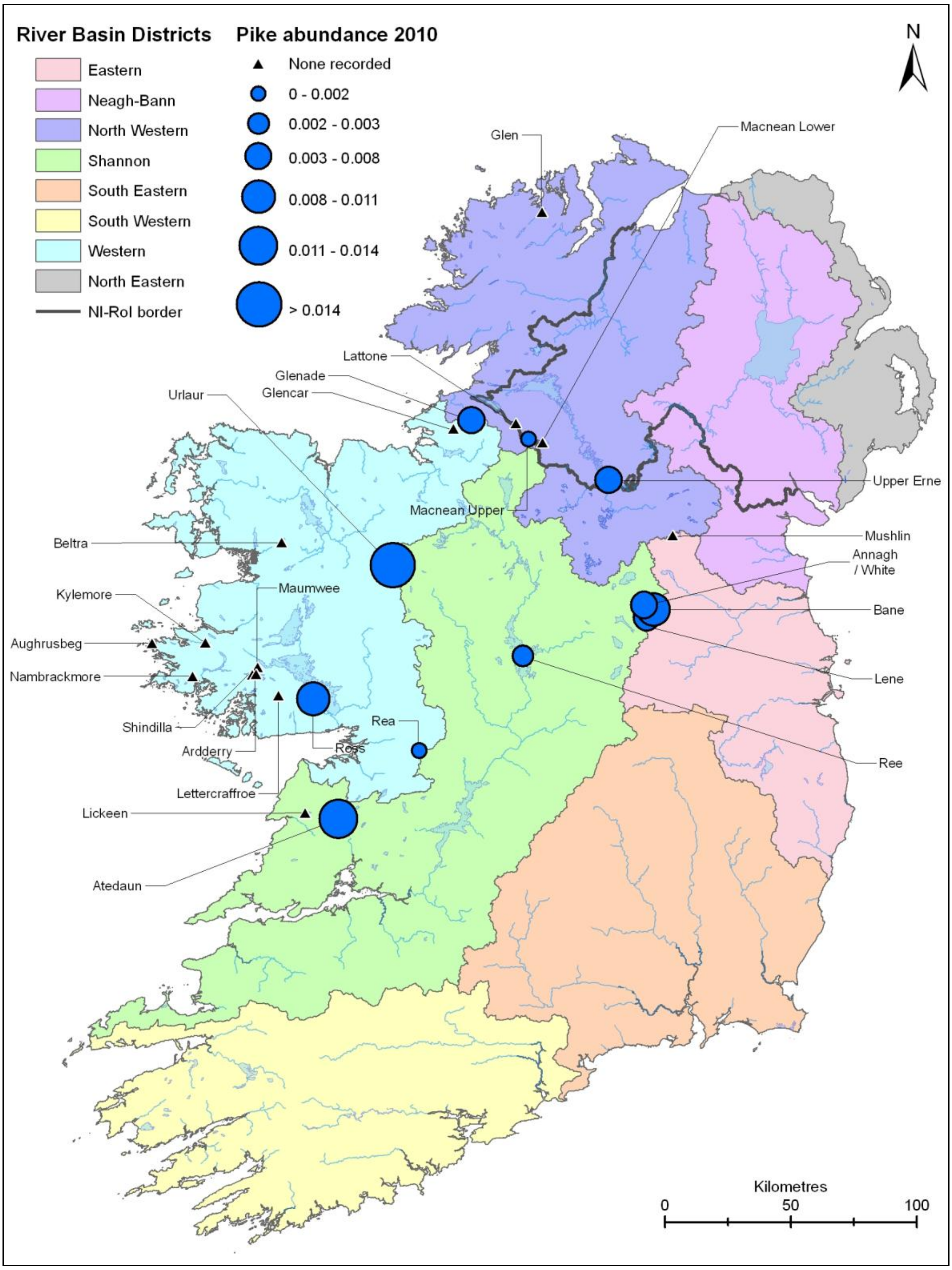

Fig. 4.10. Pike distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

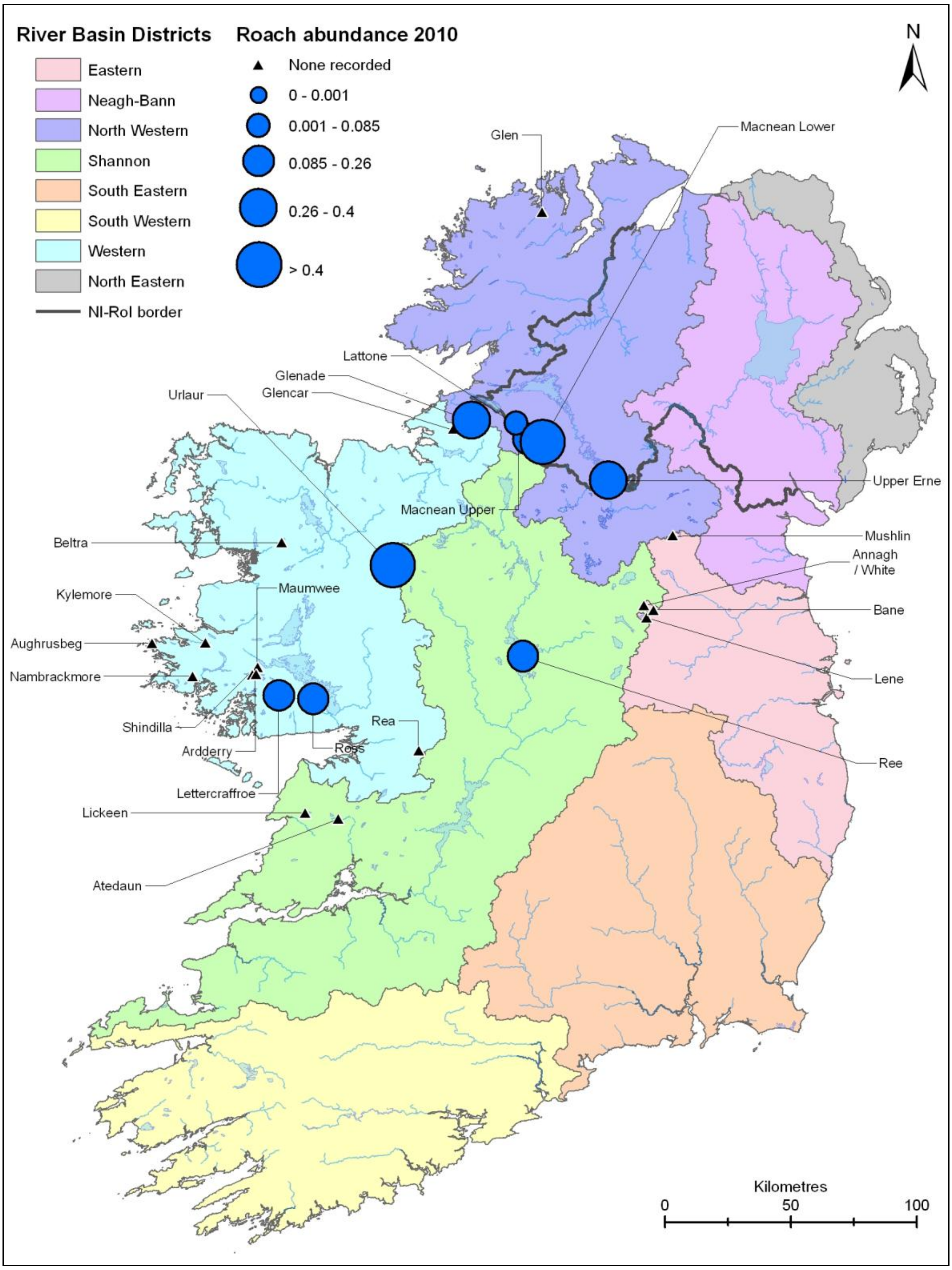

Fig. 4.11. Roach distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

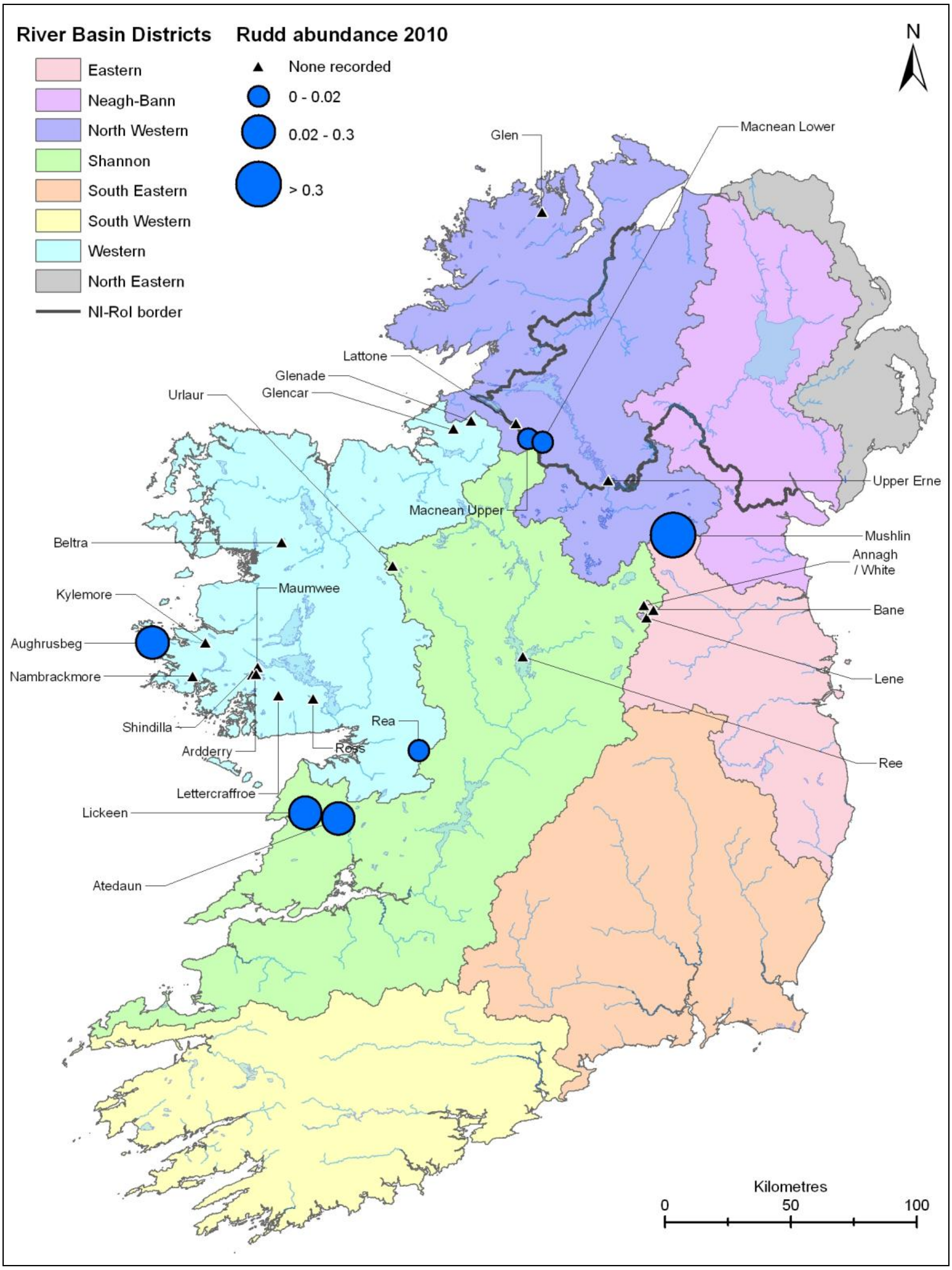

Fig. 4.12. Rudd distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

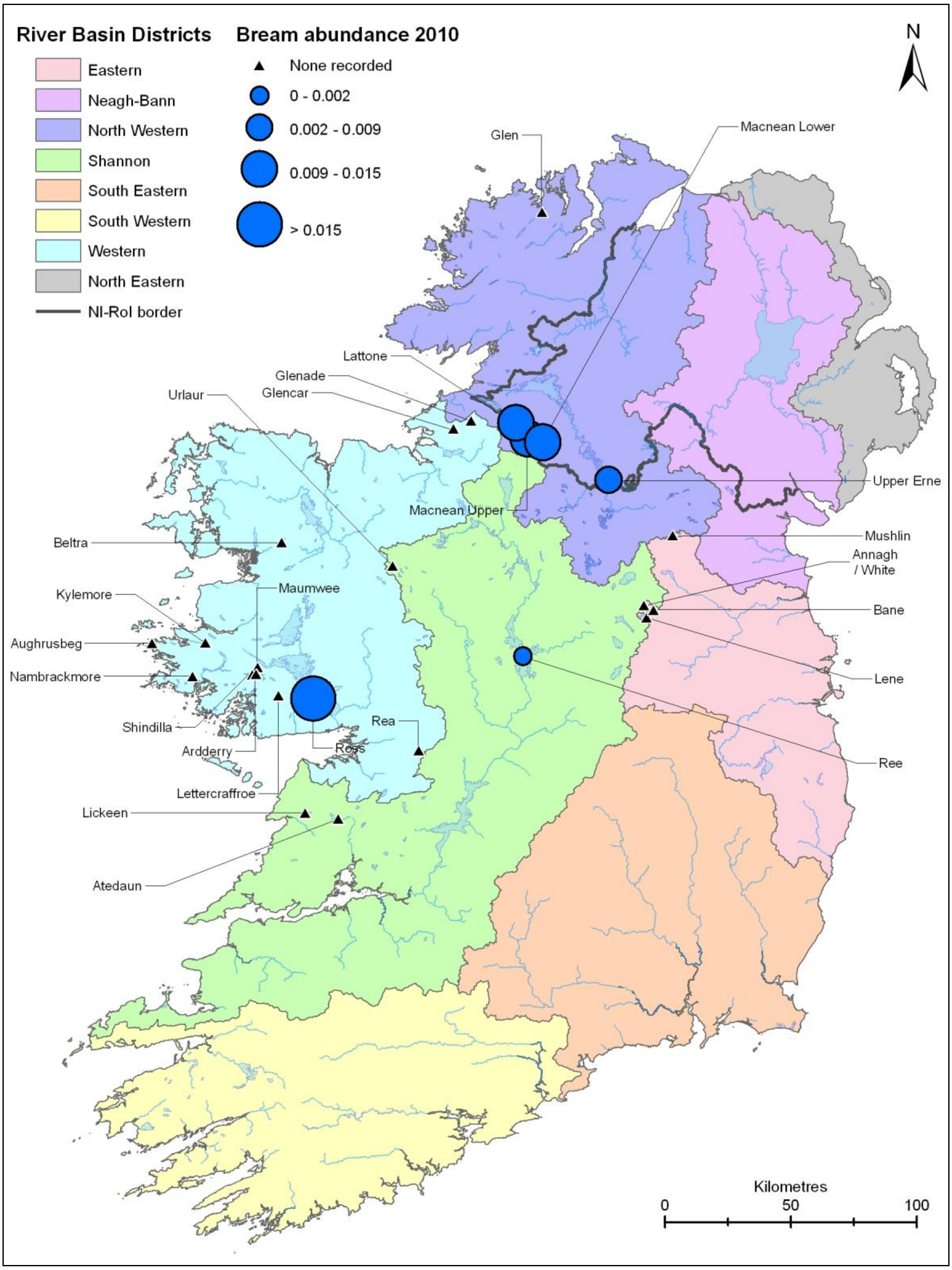

Fig. 4.13. Bream distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

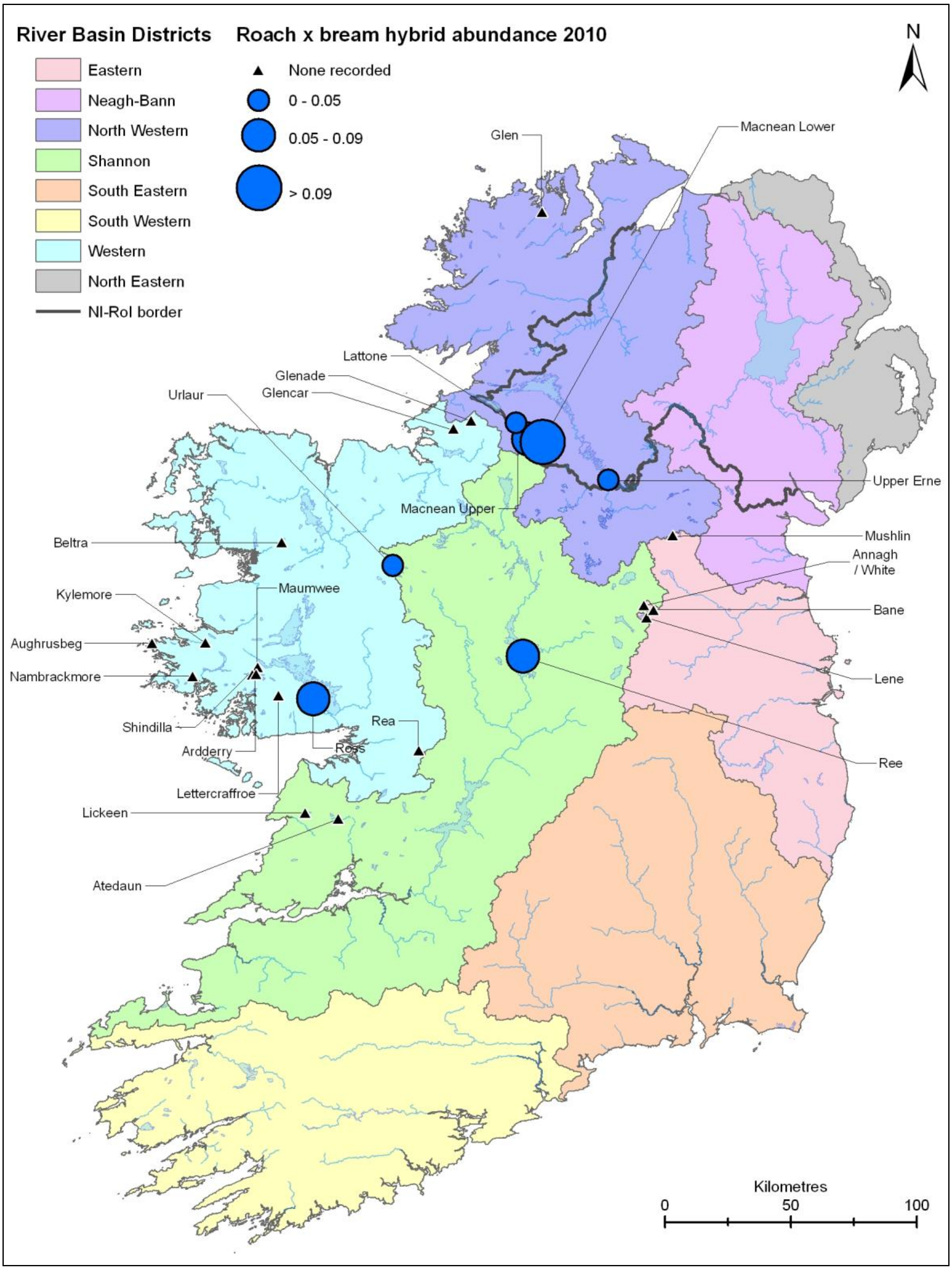

Fig. 4.14. Roach x bream hybrid distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

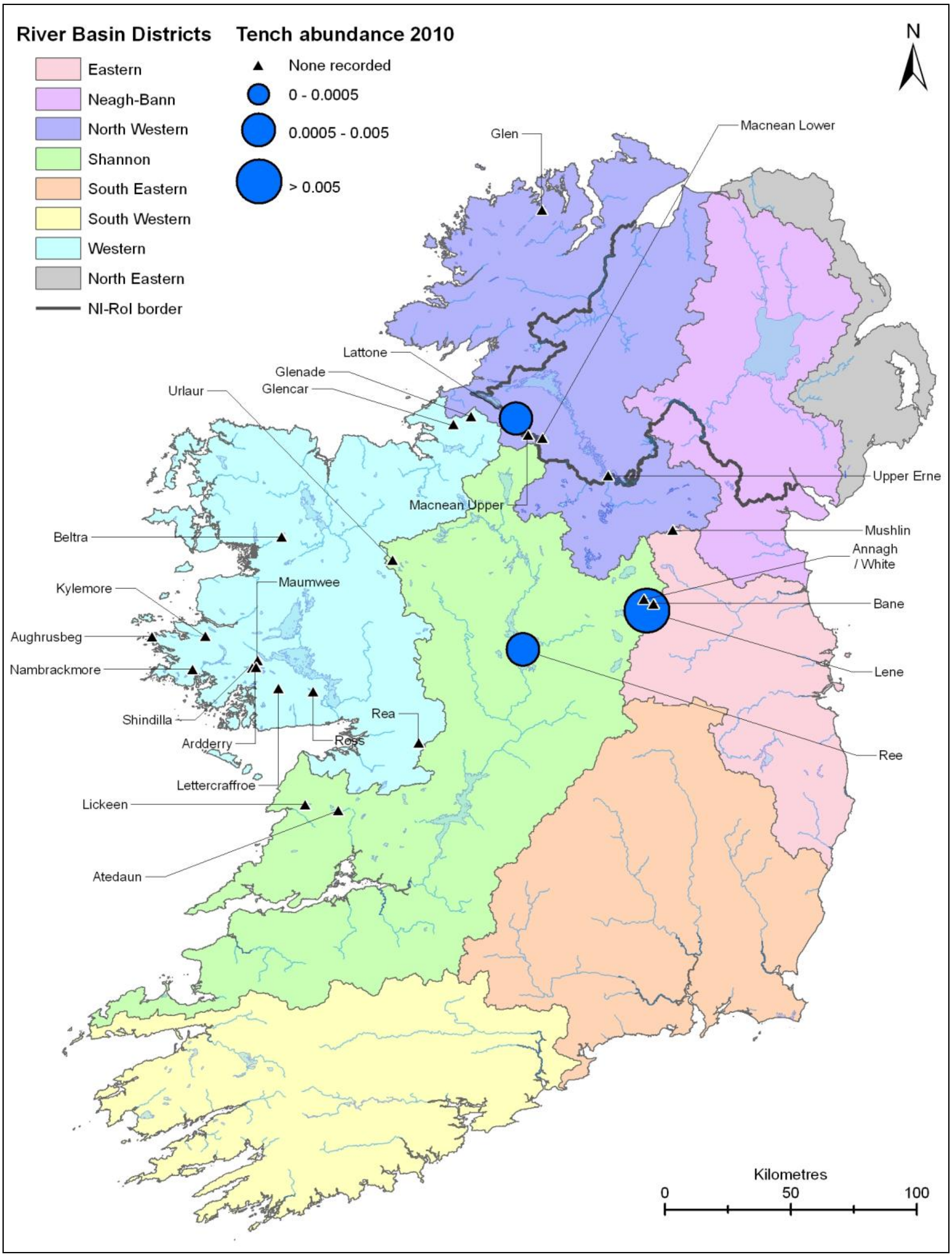

Fig. 4.15. Tench distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring during 2010

4.1.3 Fish abundance and biomass

The abundance (mean CPUE - mean number of fish/m of net) and biomass (mean BPUE - mean weight (g) of fish/m of net) of the principal fish species recorded in lakes surveyed during the 2010 surveillance monitoring programme are shown in Figures 4.16 to 4.37.

Kylemore Lough exhibited the highest abundance of eels amongst the low alkalinity lakes, Aughrusbeg Lough exhibited the highest abundance amongst the moderately alkaline lakes and Beltra Lough exhibited the highest abundance amongst the high alkalinity lakes. Kylemore Lough exhibited the highest biomass of eels amongst the low alkalinity lakes, Lough Macnean Lower exhibited the highest biomass amongst the moderately alkaline lakes and Beltra Lough exhibited the highest biomass of eels amongst the high alkalinity lakes. Overall Beltra Lough exhibited the highest abundance and Kylemore Lough exhibited the highest biomass of eels amongst all lakes surveyed during 2010 (Figs. 4.16 and 4.17).

Maumwee Lough (a low alkalinity lake in Co. Galway) exhibited both the highest abundance and the highest biomass of brown trout amongst all lakes surveyed (Figs. 4.18 and 4.19).

Kylemore Lough exhibited both the highest abundance and the highest biomass of sea trout amongst all lakes surveyed (Figs. 4.20 and 4.21).

Glen Lough (low alkalinity) exhibited the highest abundance and Lough Shindilla (low alkalinity) exhibiting the highest biomass of char (Figs. 4.22 and 4.23).

Ardderry Lough exhibited both the highest abundance and highest biomass of perch amongst the low alkalinity lakes. Lattone Lough exhibited both the highest abundance and highest biomass of perch amongst the moderate alkalinity lakes. Lough Mushlin had the highest perch abundance and Lough Rea exhibited the highest perch biomassamongst the high alkalinity lakes (Figs. 4.24 and 4.25).

Lough Macnean Lower exhibited the highest abundance and Glenade Lough exhibited the highest biomass of roach amongst the moderate alkalinity lakes. Urlaur Lough exhibited both the highest abundance and the highest biomass of roach amongst the high alkalinity lakes (Figs. 4.26 and 4.27).

Lough Lene exhibited both the highest abundance and the highest biomass of pike amongst the moderate alkalinity lakes. Urlaur Lough exhibited the highest abundance and Ross Lake exhibited the highest biomass of pike amongst the high alkalinity lakes (Figs. 4.28 and 4.29).

Lattone Lough exhibited the highest abundance and Upper Lough Erne exhibited the highest biomass of bream amongst the moderate alkalinity lakes. Ross Lake exhibited both the highest abundance and the highest biomass of bream amongst the high alkalinity lakes (Figs. 4.30 and 4.31).

Lough Lene (moderate alkalinity) exhibited both the highest abundance and the highest biomass of tench amongst the three lakes (Figs. 4.32 and 4.33).

Lickeen Lough exhibited both the highest abundance and the highest biomass of rudd amongst the moderate alkalinity lakes. Lough Mushlin exhibited both the highest abundance and the highest biomass of rudd amongst the high alkalinity lakes (Figs. 4.34 and 4.35).

The highest abundance of roach x bream hybrids was recorded in Lough MacNean Lower (moderate alkalinity) and the highest biomass of roach x bream hybrids was recorded in Lough Ree (high alkalinity) (Figs. 4.36 and 4.37).

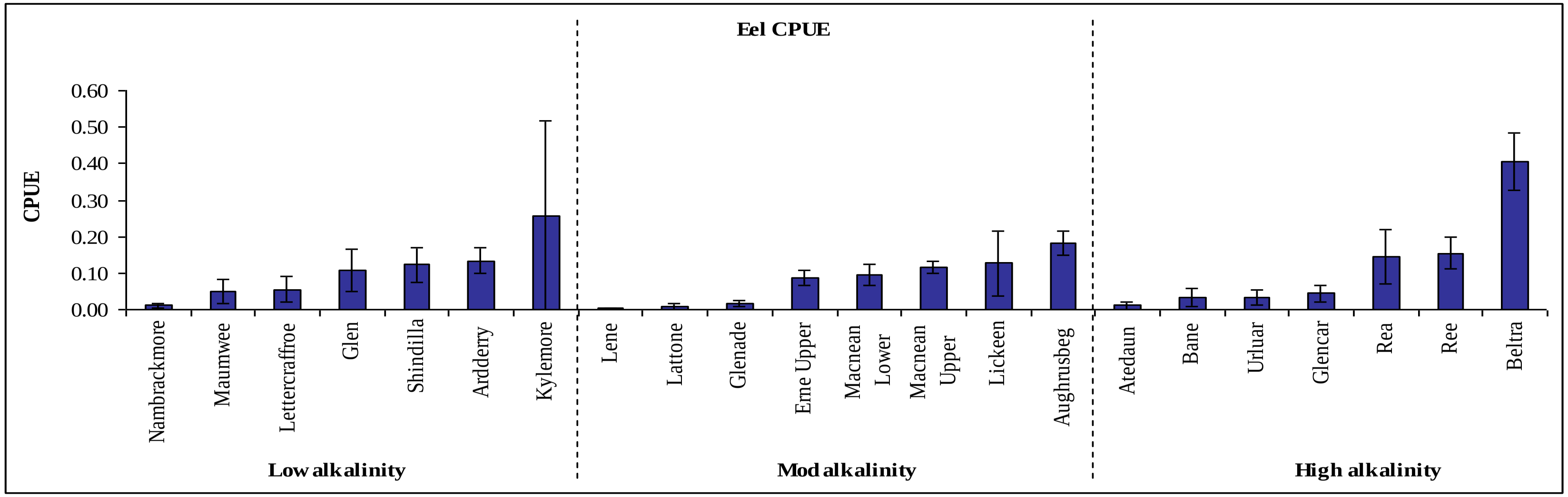

Fig. 4.16. Eel abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

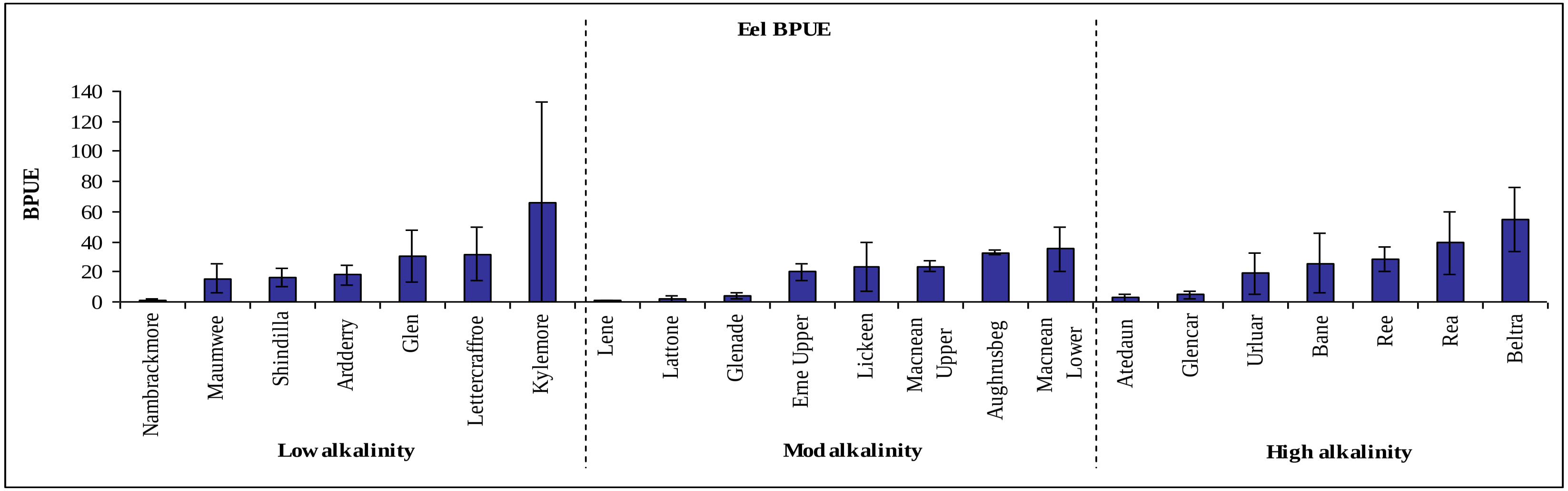

Fig. 4.17. Eel biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

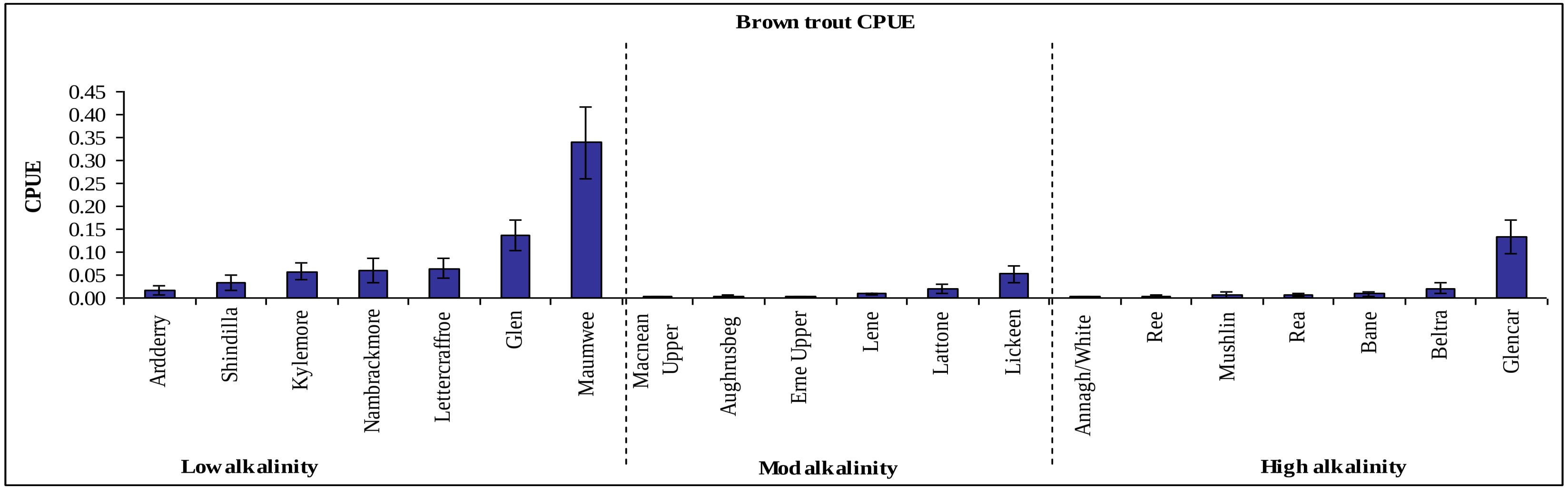

Fig. 4.18. Brown trout abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

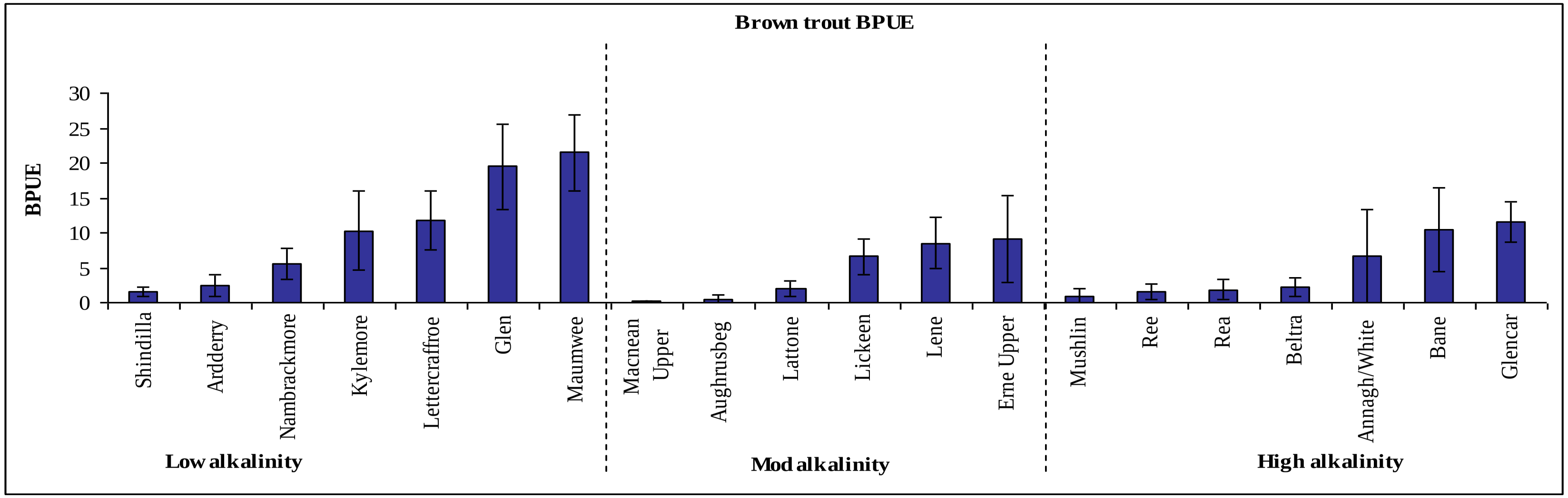

Fig. 4.19. Brown trout biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

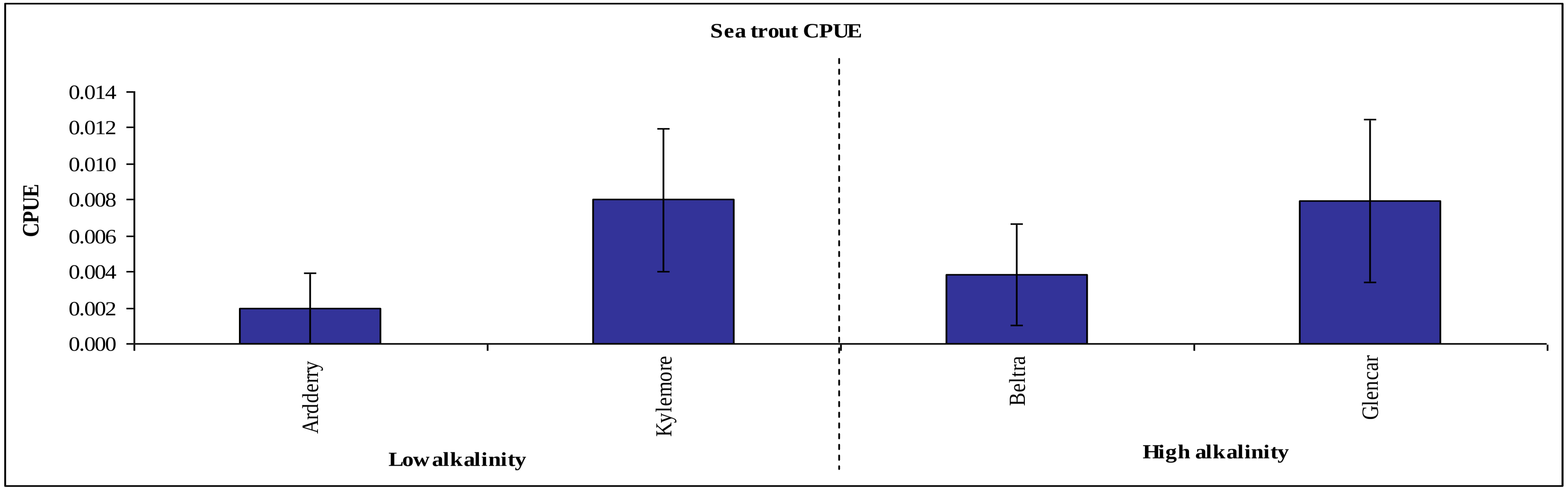

Fig. 4.20. Sea trout abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

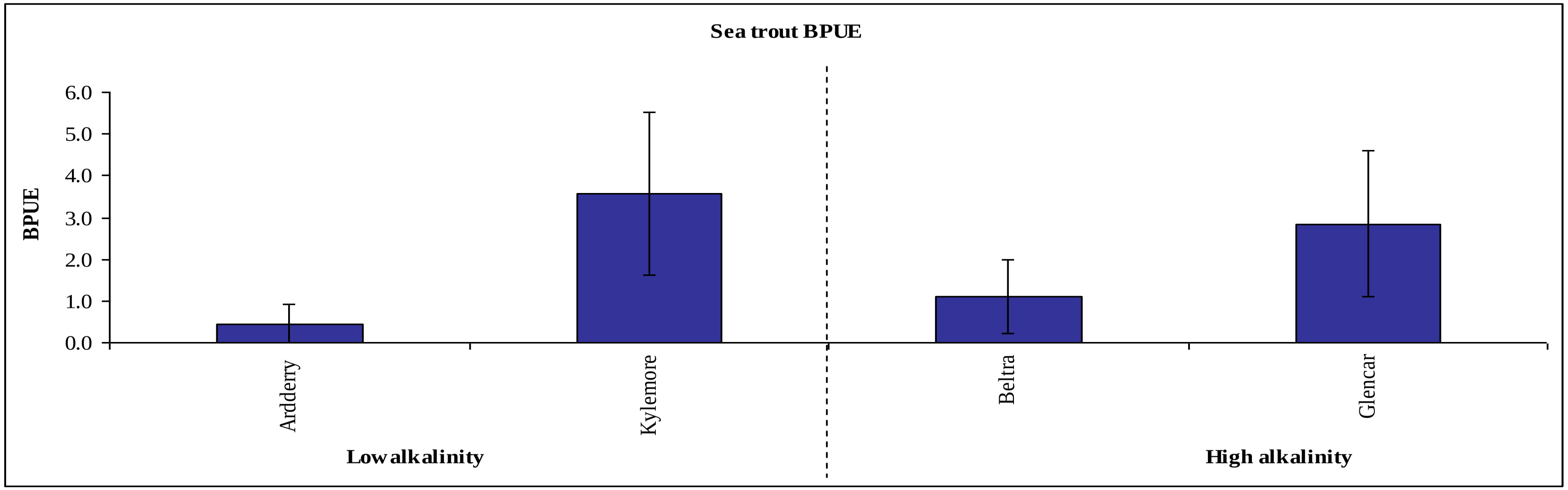

Fig. 4.21. Sea trout biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

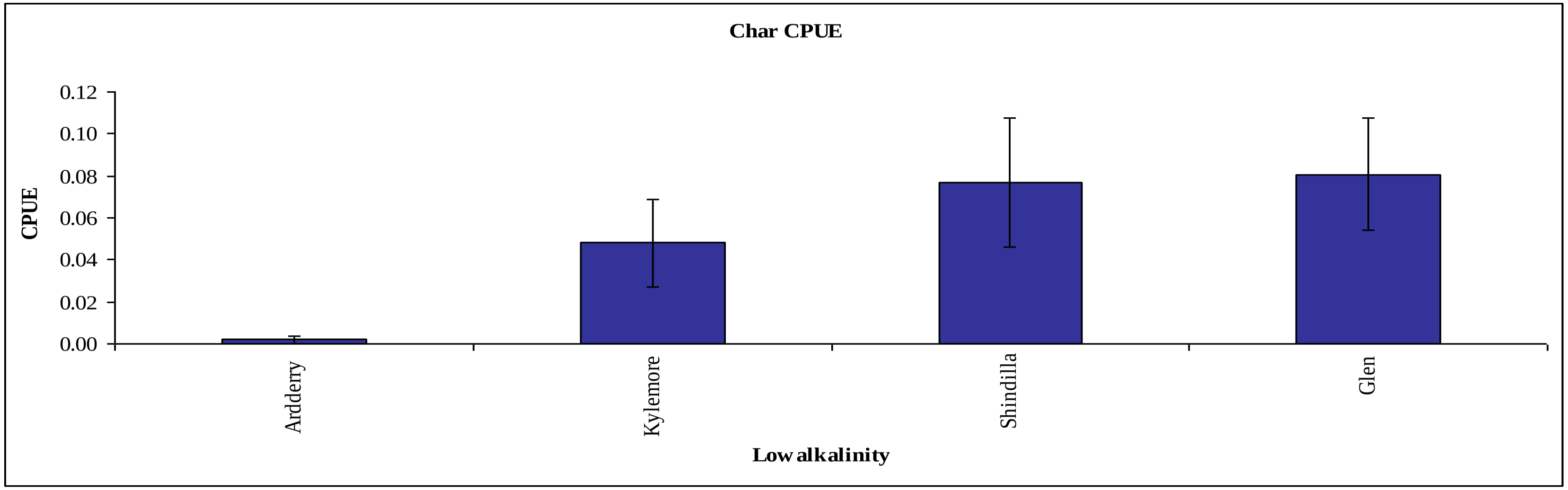

Fig. 4.22. Char abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

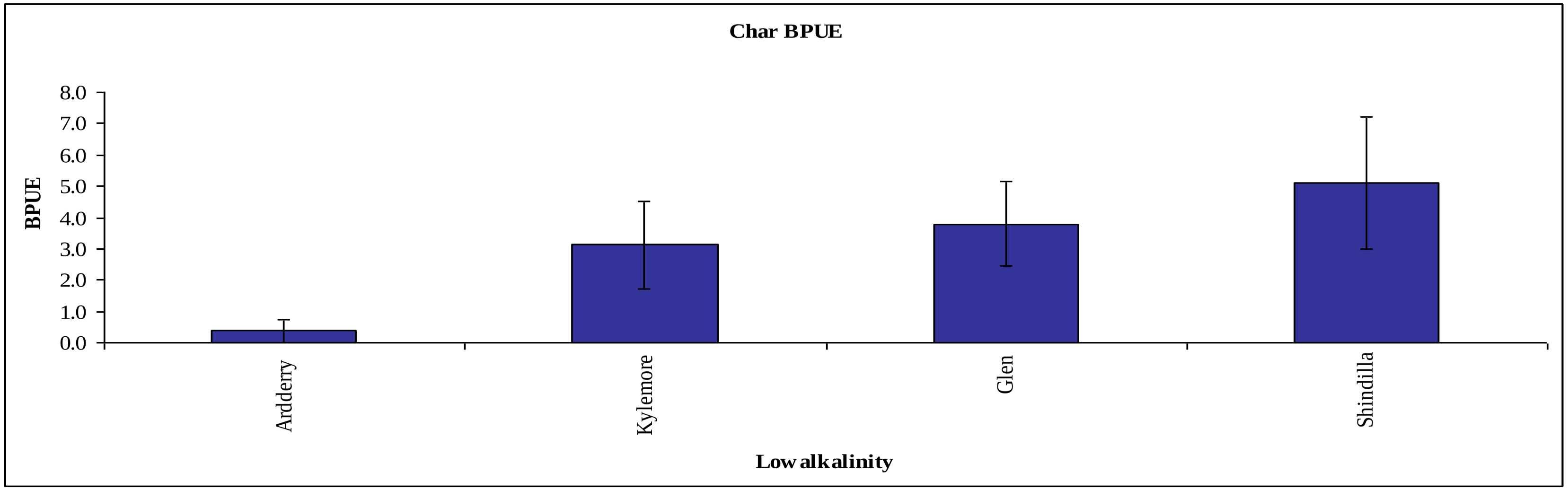

Fig. 4.23. Char biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

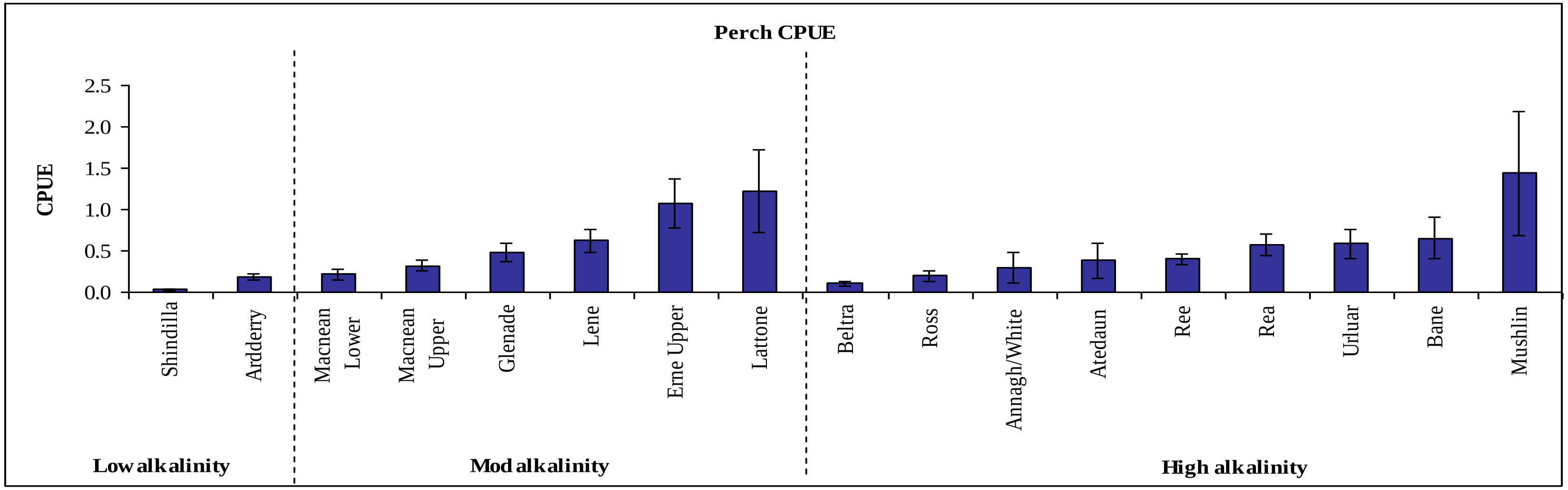

Fig. 4.24. Perch abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

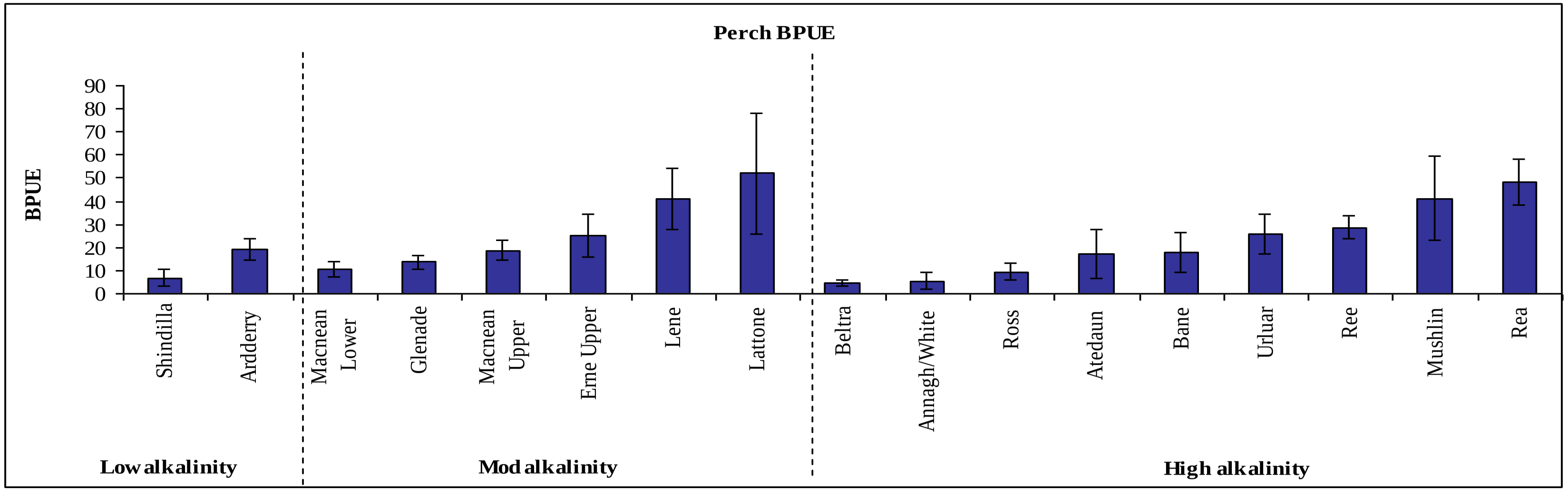

Fig. 4.25. Perch biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

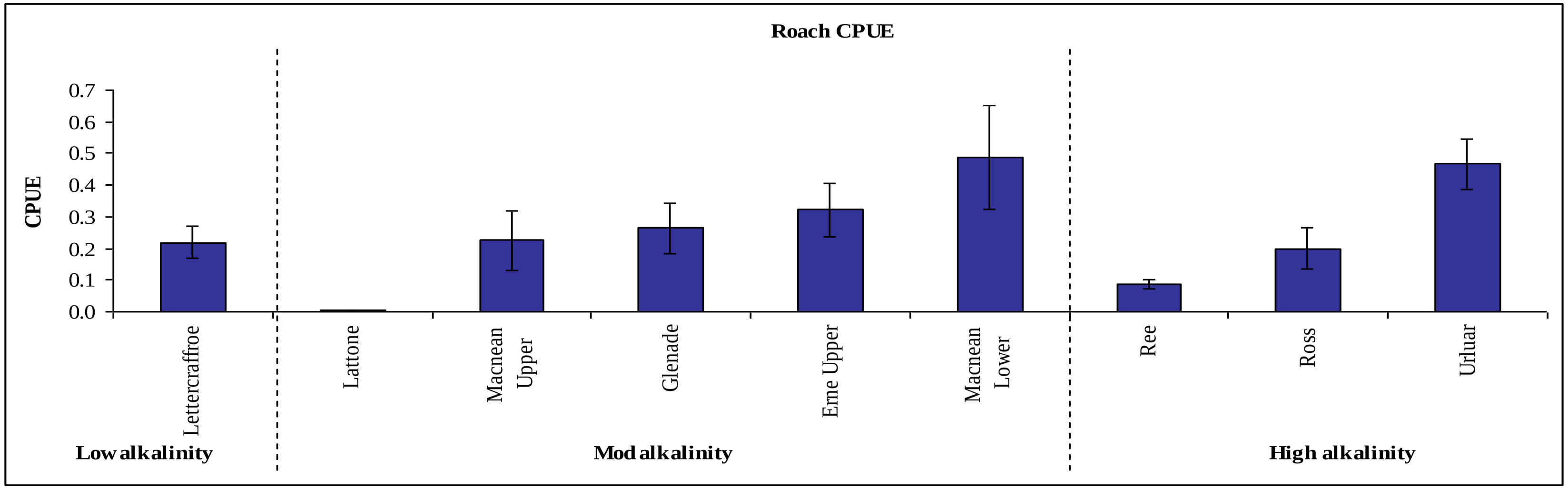

Fig. 4.26. Roach abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

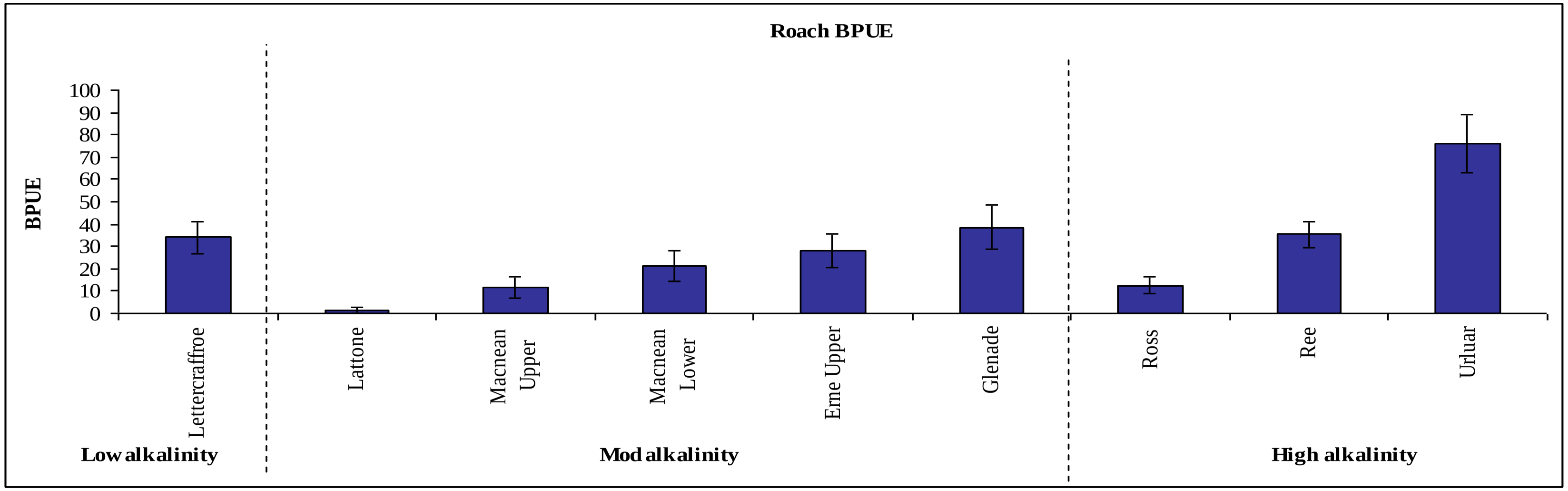

Fig. 4.27. Roach biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

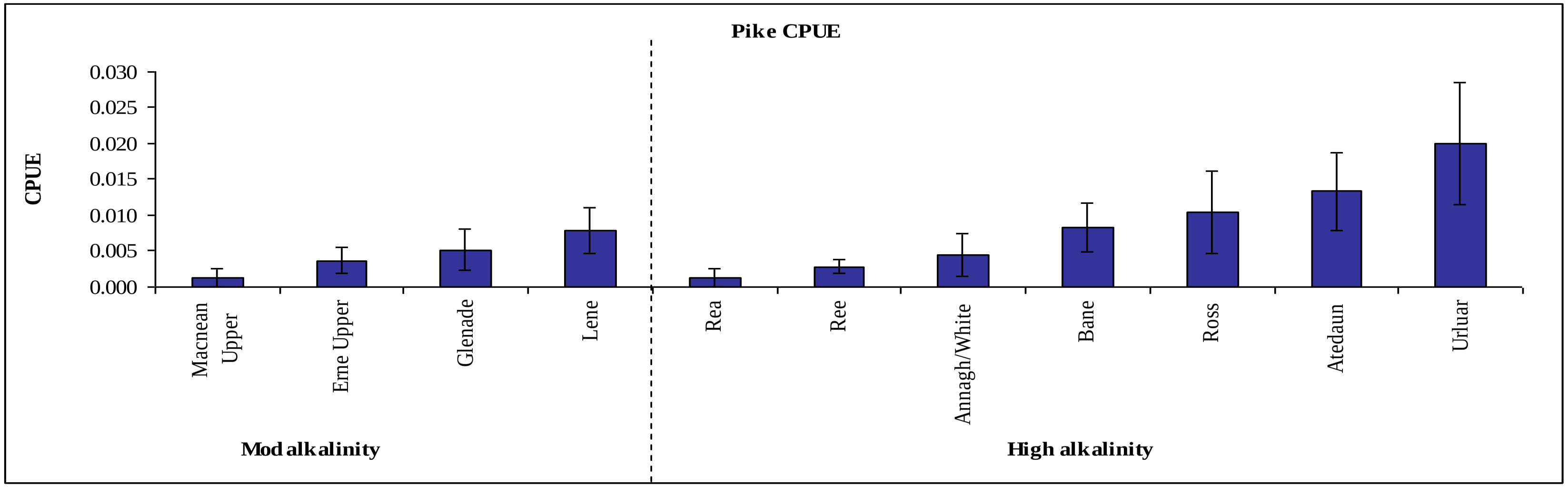

Fig. 4.28. Pike abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

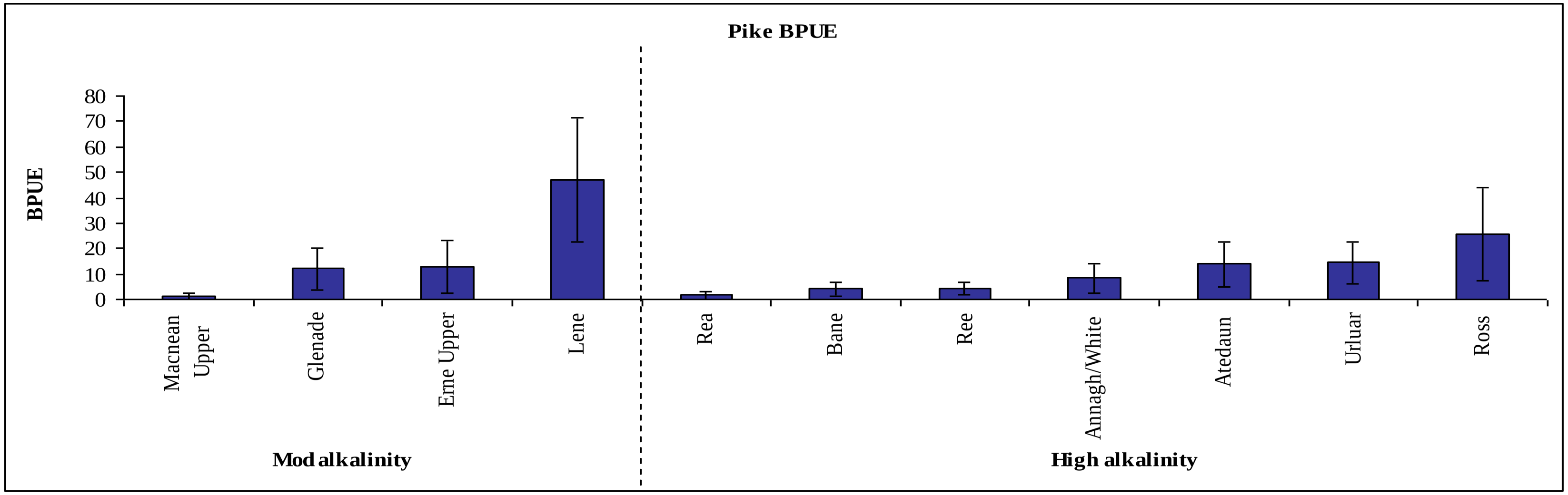

Fig. 4.29. Pike biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

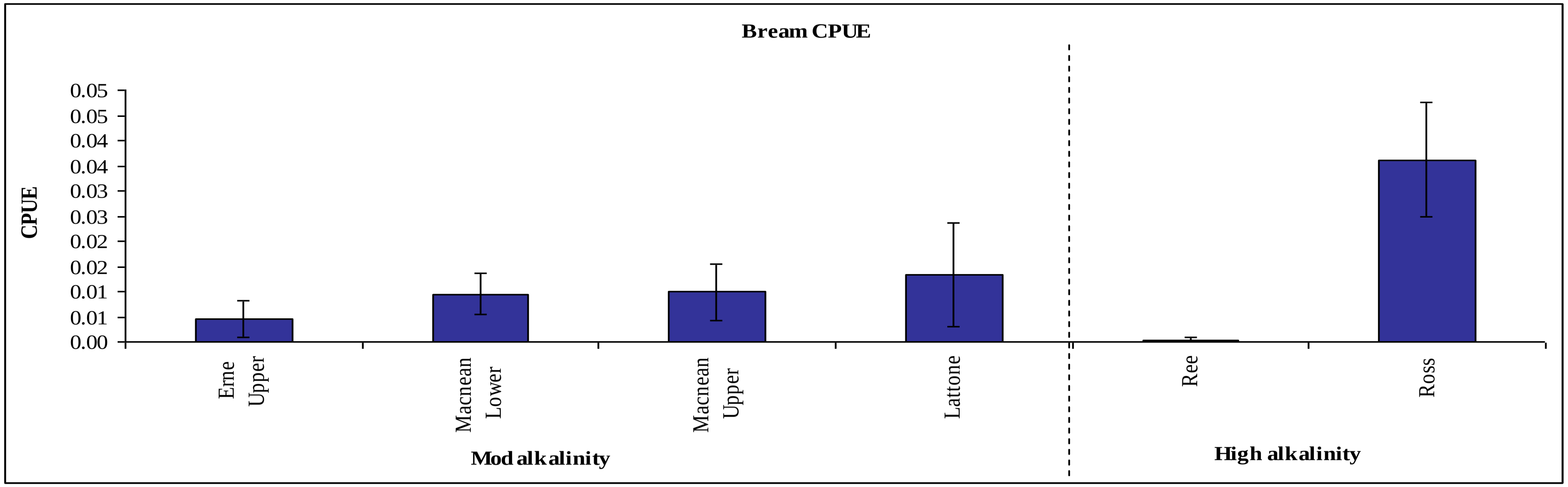

Fig. 4.30. Bream abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

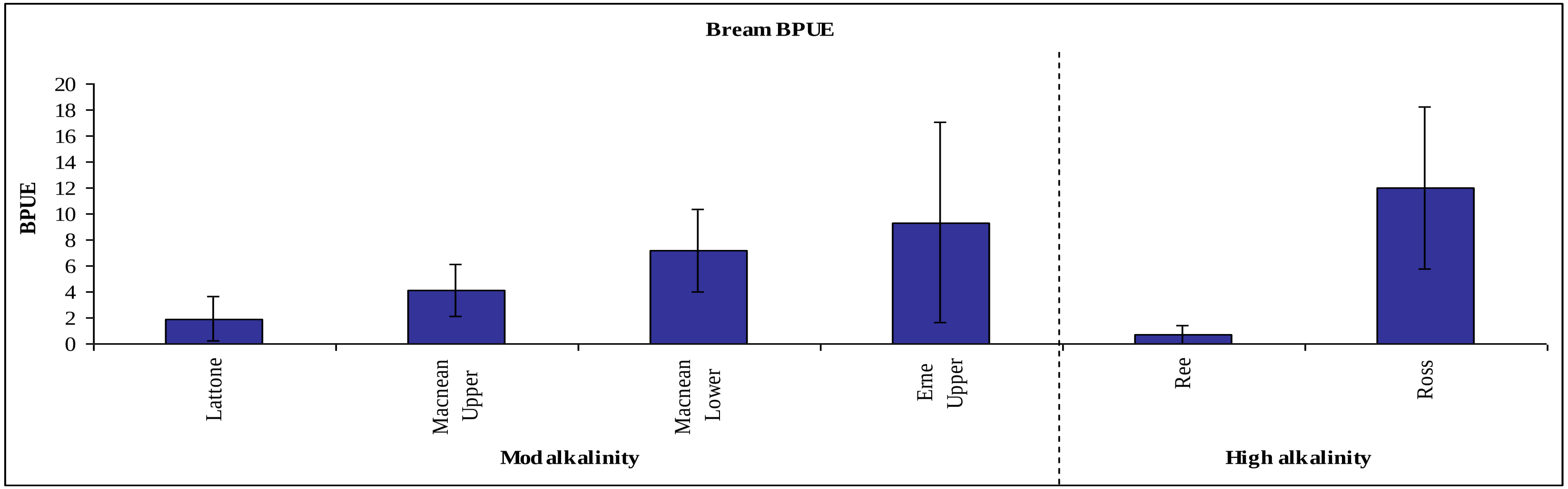

Fig. 4.31. Bream biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

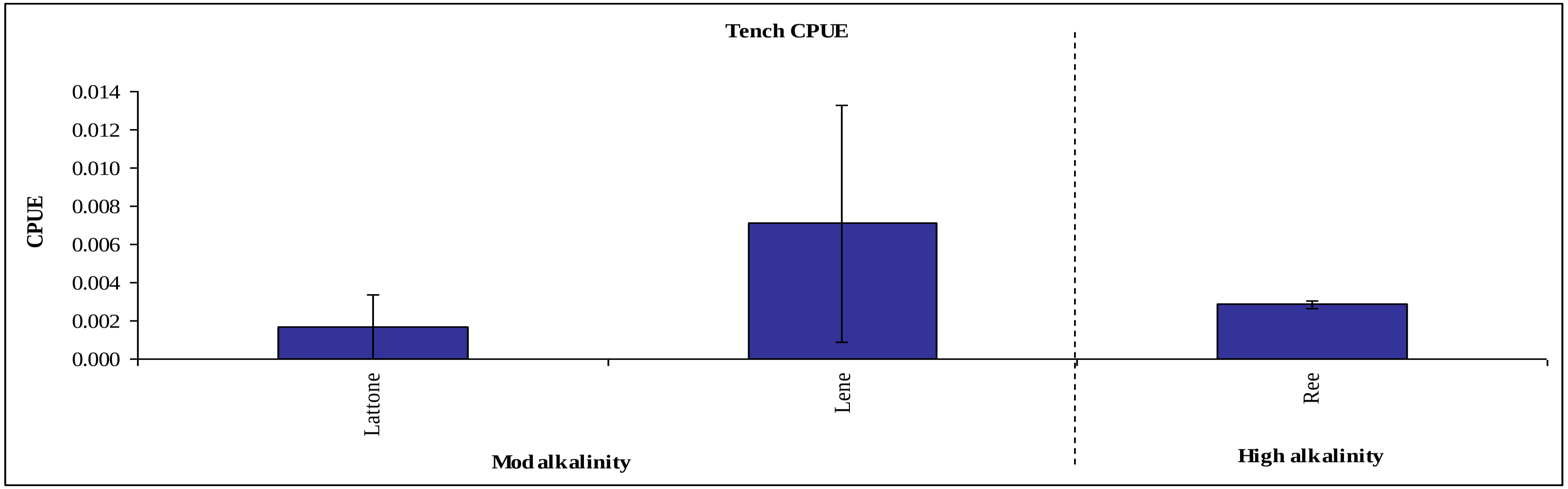

Fig. 4.32. Tench abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

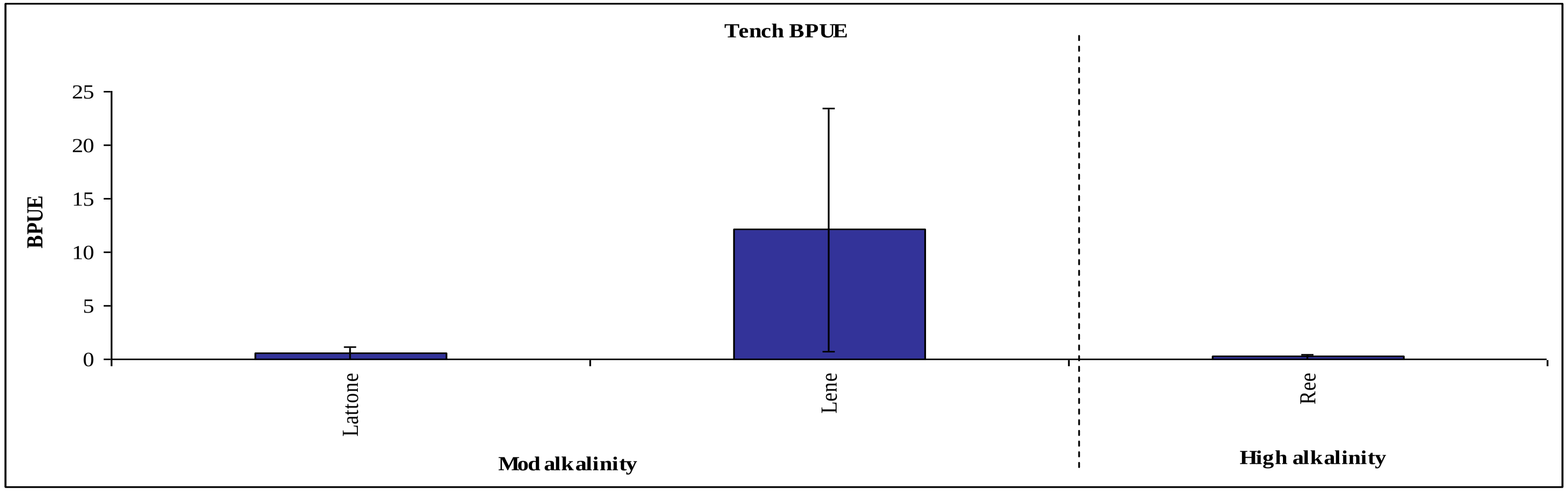

Fig. 4.33. Tench biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

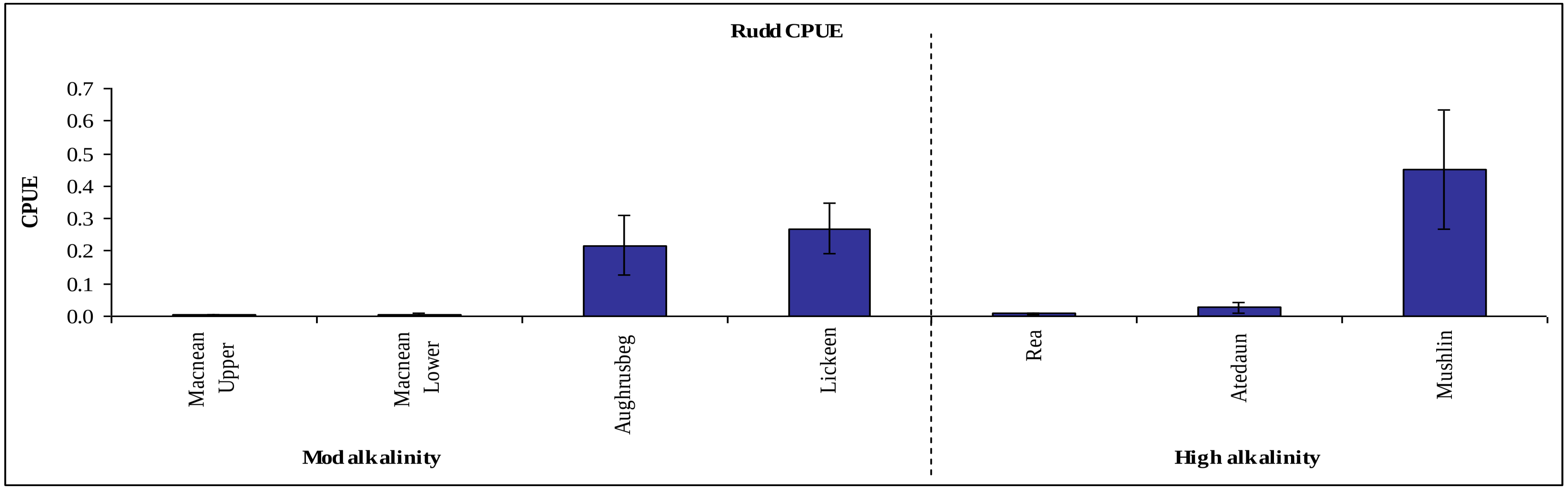

Fig. 4.34. Rudd abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2010

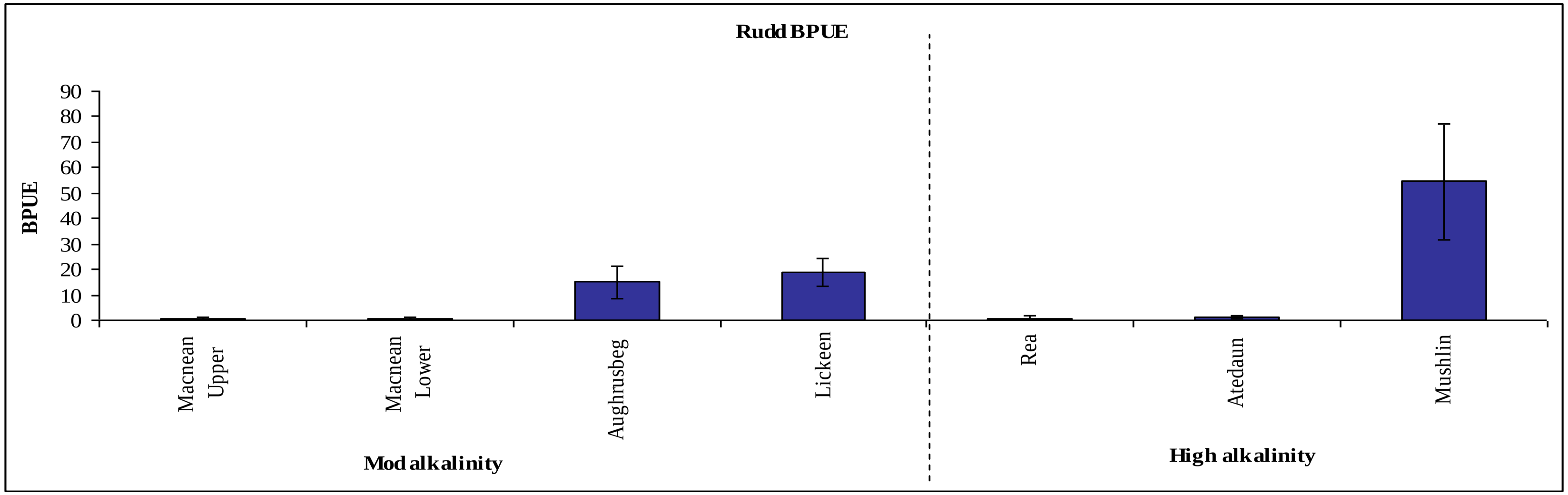

Fig. 4.35. Rudd biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2010

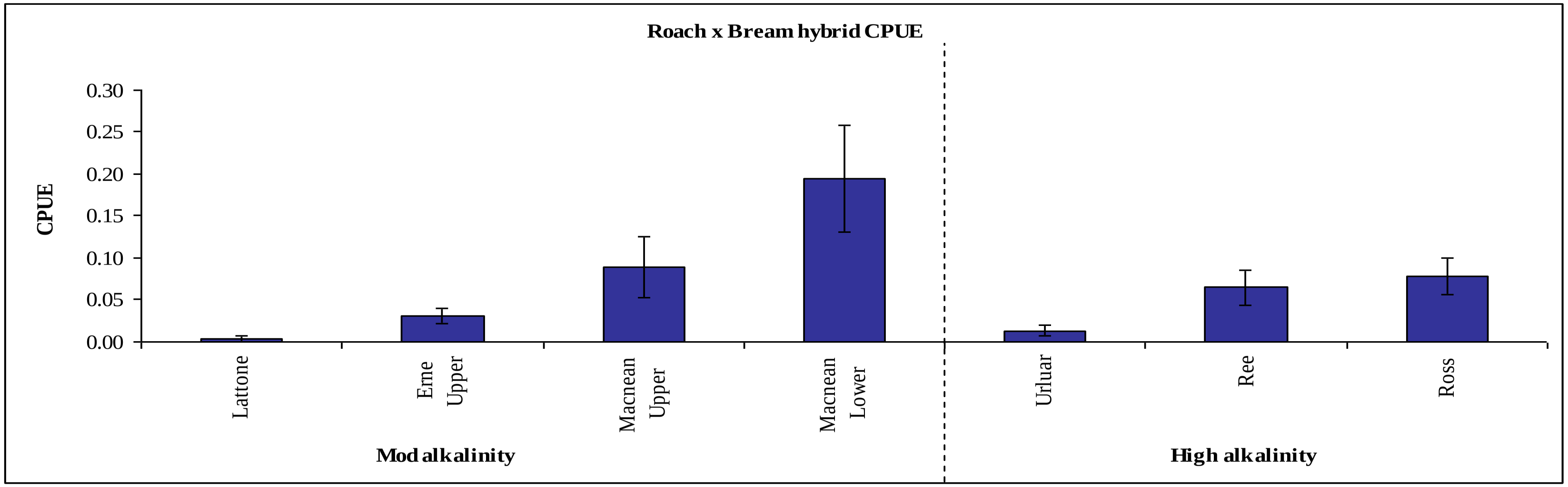

Fig. 4.36. Roach x bream abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring

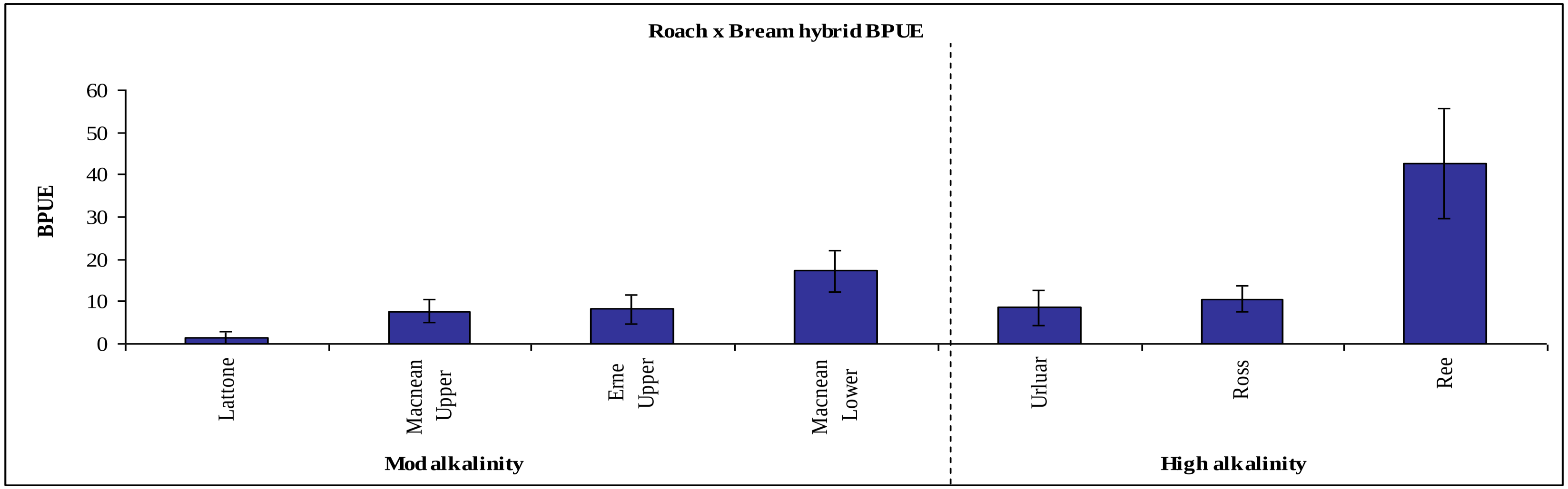

Fig. 4.37. Roach x bream biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish

4.1.4 Fish growth

4.1.4.1 Growth of brown trout, perch and roach

Scales from 399 brown trout (20 lakes), 548 roach (9 lakes), 183 rudd (7 lakes),39 bream(6 lakes),179 roach x bream (7 lakes), otoliths from 114 char (4 lakes) and opercular bones from 1,468 perch (17 lakes) were examined for age and growth analysis. Mean lengths at age (L1 = back calculated length at the end of the first winter, etc.) for the three dominant species; brown trout, perch and roach were back-calculated and growth curves plotted (Figs. 4.38 to 4.40). Details of back calculated mean lengths at age for brown trout, perch and roach are given in Appendices 3, 4 and 5 respectively.

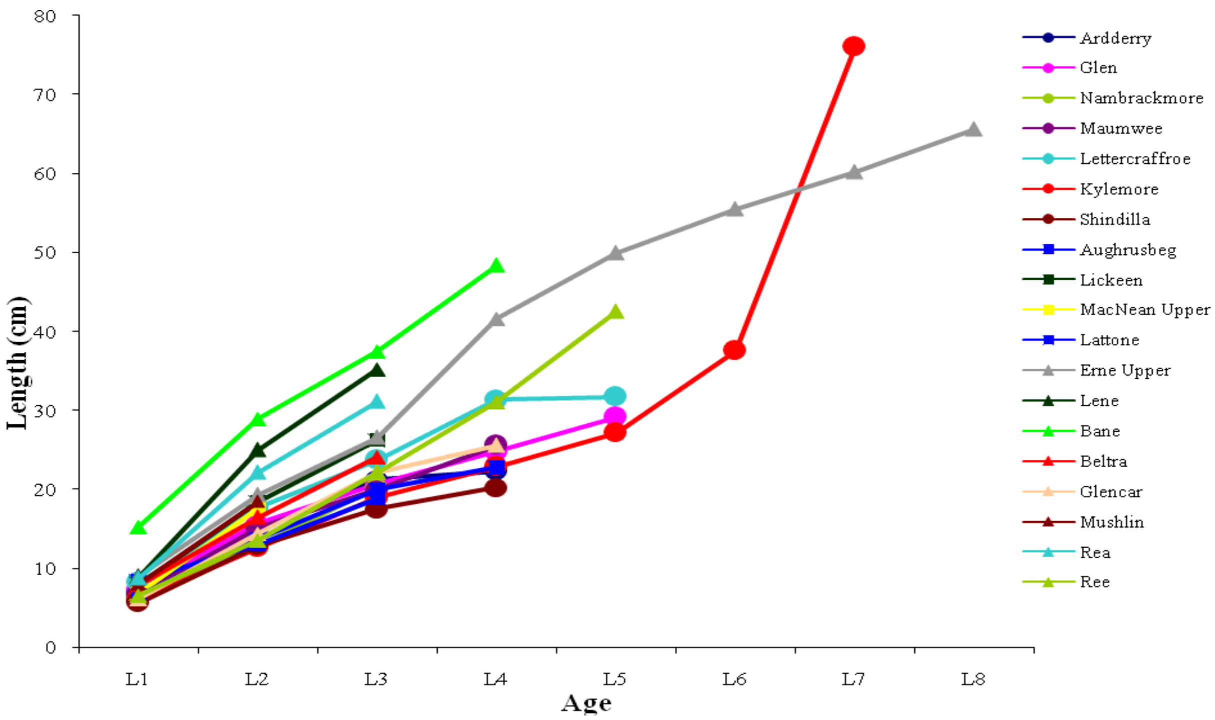

Fig. 4.38. Mean lengths at age of brown trout in lakes surveyed for WFD fish monitoring 2010 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

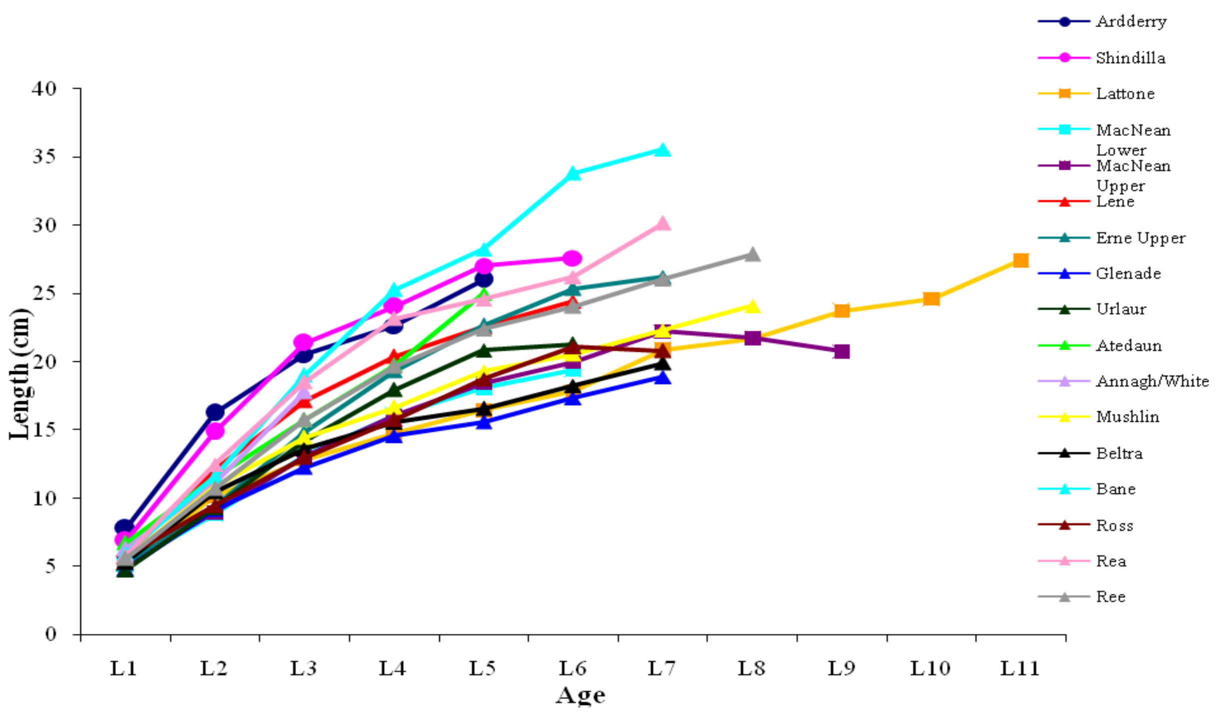

Fig. 4.39. Mean lengths at age of perch in lakes surveyed for WFD fish monitoring 2010 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

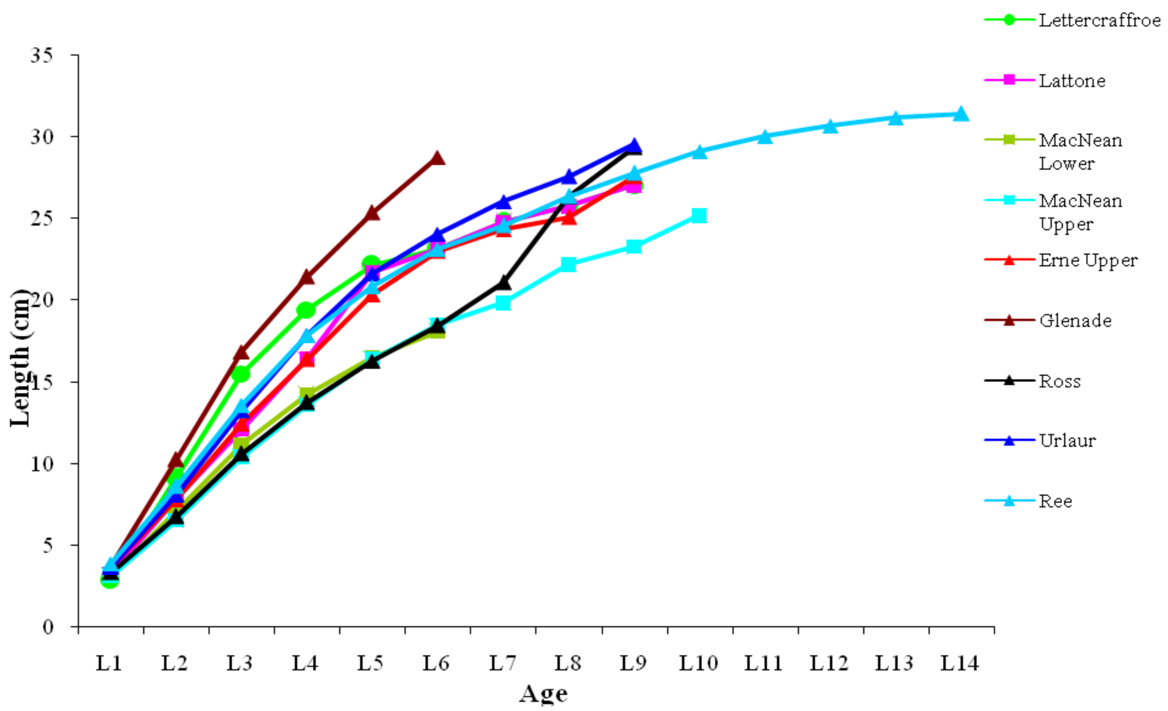

Fig. 4.40. Mean lengths at age of roach in lakes surveyed for WFD fish monitoring 2010 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

4.1.4.2 Growth of brown trout in low, moderate and high alkalinity lakes

Brown trout from many of the high alkalinity lakes surveyed during 2010displayed faster growth than those from the low and moderate alkalinity lakes (Fig. 4.38). Differences in mean length at age among the three alkalinity groups for L1 to L5 were assessed using a one-way ANOVA and were not statistically significant (Fig. 4.41).

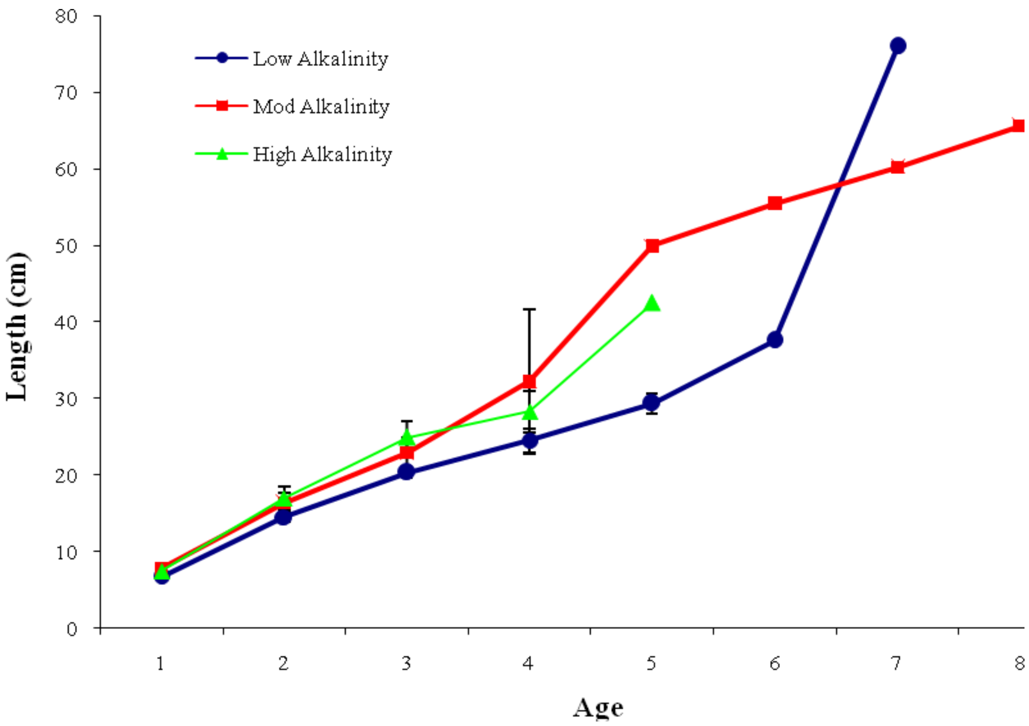

Fig 4.41. Mean (±SE) lengths at age of brown trout in lakes surveyed for WFD fish monitoring 2010

Kennedy and Fitzmaurice (1971) related brown trout growth rates to alkalinity, classifying the growth of brown trout in lakes into the following four categories based on the mean length at the end of the fourth year (L4):

1) very slow – mean L4 = 20–25cm
2) slow – mean L4 = 25–30cm
3) fast – mean L4 = 30–35cm
4) very fast – mean L4 = 35–40cm

This classification was applied to the brown trout captured from eleven lakes (Table 4.3).Trout from Aughrusbeg Lough, Beltra Lough, Lough Nambrackmore, Annagh/White Lough, Lough Mushlin, Lough Lene, Lickeen Lough, Lough MacNean Upper and Lough Rea were not classified as there were no four year old fish captured on these lakes.

Table 4.3. Categories of growth of trout in lakes as per Kennedy and Fitzmaurice (1971)

Very slow	Slow	Fast	Very fast
Ardderry	Maumwee	Lettercraffroe	Bane
Glen	Glencar	Ree	Erne Upper
Lattone			
Kylemore			
Shindilla			

4.1.4.3 Growth of non-native fish species in low, moderate and high alkalinity lakes

Both perch and roach were recorded in low, moderate and high alkalinity lakes. The mean length at age of both perch and roach were greater in the low alkalinity lakes than in the moderate and high alkalinity lakes (Figs. 4.42 and 4.43). One-way ANOVAs were used to assess whether these differences were statistically significant, with the results showing that perch mean L1, L2, L3 and L5 from low alkalinity lakes were significantly higher than moderate and high alkalinity lakes (L1 - $F_{2, 16}$=13.378, P=0.001; L2 - $F_{2, 16}$=21.968, P=0.000; L3 - $F_{2, 15}$=9.563, P=0.002; L5 - $F_{2, 15}$=3.898, P=0.047).

Appendices 4 and 5 give a summary of the mean back calculated lengths at age of perch and roach from the 13 and 6 lakes respectively.

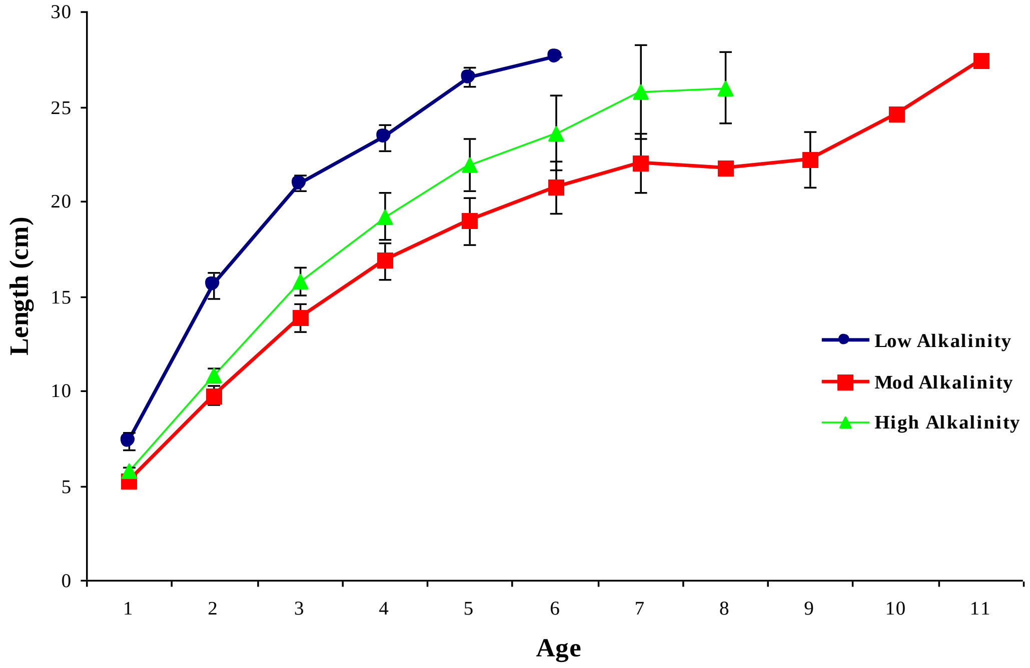

Fig 4.42. Mean (±SE) length at age of perch in lakes surveyed for WFD fish monitoring 2010

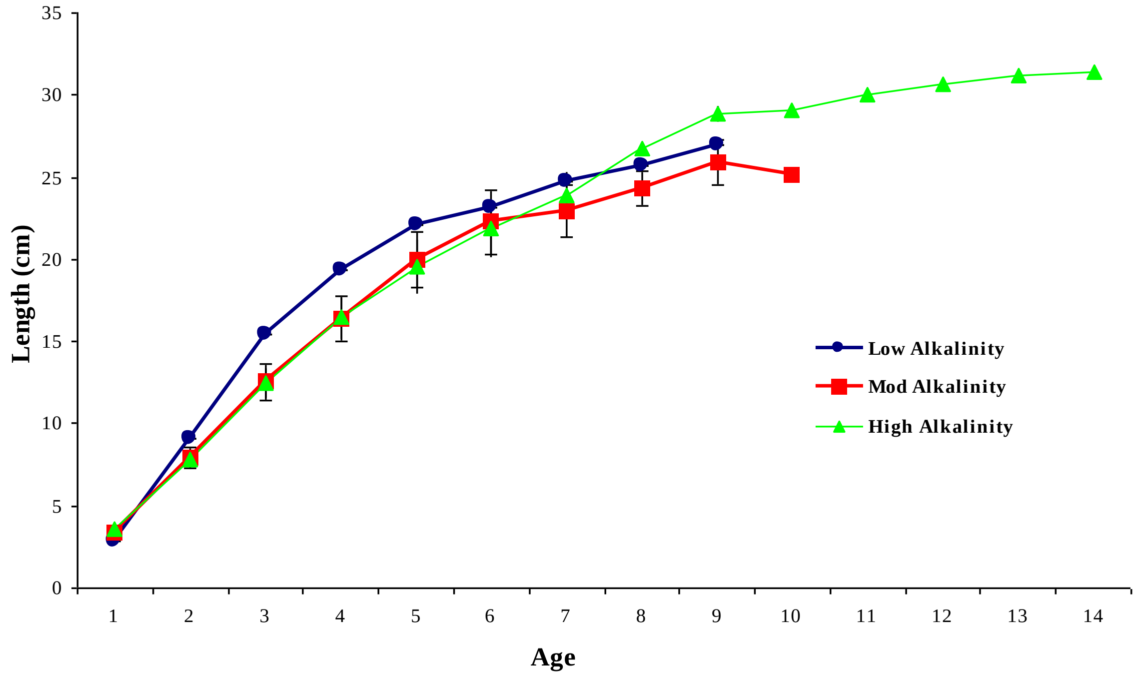

Fig 4.43. Mean (±SE) length at age of roach in lakes surveyed for WFD fish monitoring 2010

4.1.5 Ecological status - Classification of lakes using 'FIL2'

An essential step in the WFD monitoring process is the classification of the ecological status of lakes, which in turn will assist in identifying the objectives that must be set in the individual River Basin Management Plans (RBMPs).

The Fish in Lakes ecological classification tool (FIL2) is designed to assign lakes in Ecoregion 17 (Ireland) to ecological status classes ranging from High to Bad using fish population parameters relating to abundance, species composition and age structure. FIL2 is a further development of the original FIL1 ecological classification tool (Kelly *et. al.*, 2008b). It combines a discriminant analysis model, providing a discrete assessment of status class with an EQR model, providing a WFD compliant quantitative EQR output of between 0 and 1.

All 25 lakes surveyed during 2010 were assigned a draft ecological status class using the FIL2 ecological classification tool; six were classified as High, eight were classified as Good, one was classified as Moderate and ten were classified as Poor/Bad ecological status (Table 4.4, Figure 4.44). The full output from the FIL2 ecological classification tool is given in Appendix 6.

Table 4.4. Classification of lakes using the Fish in lakes (FIL2) classification tool

Lake	FIL2 Typology	EQR Classification (FIL2 Tool)
Shindilla	2	High
Nambrackmore	1	High
Maumwee	1	High
Glencar	4	High
Glen	1	High
Beltra	4	High
Rea	4	Good
Macnean Upper	2	Good
Lettercraffroe	2	Good
Kylemore	2	Good
Bane	3	Good
Atedaun	3	Good
Ardderry	1	Good
Annagh/White Lough	4	Good
Glenade	3	Moderate
Urluar	3	Poor/Bad
Ross (Corrib)	3	Poor/Bad
Ree	4	Poor/Bad
Mushlin	3	Poor/Bad
Macnean Lower	1	Poor/Bad
Lickeen	2	Poor/Bad
Lene	4	Poor/Bad
Lattone	1	Poor/Bad
Erne Upper	3	Poor/Bad
Aughrusbeg	1	Poor/Bad

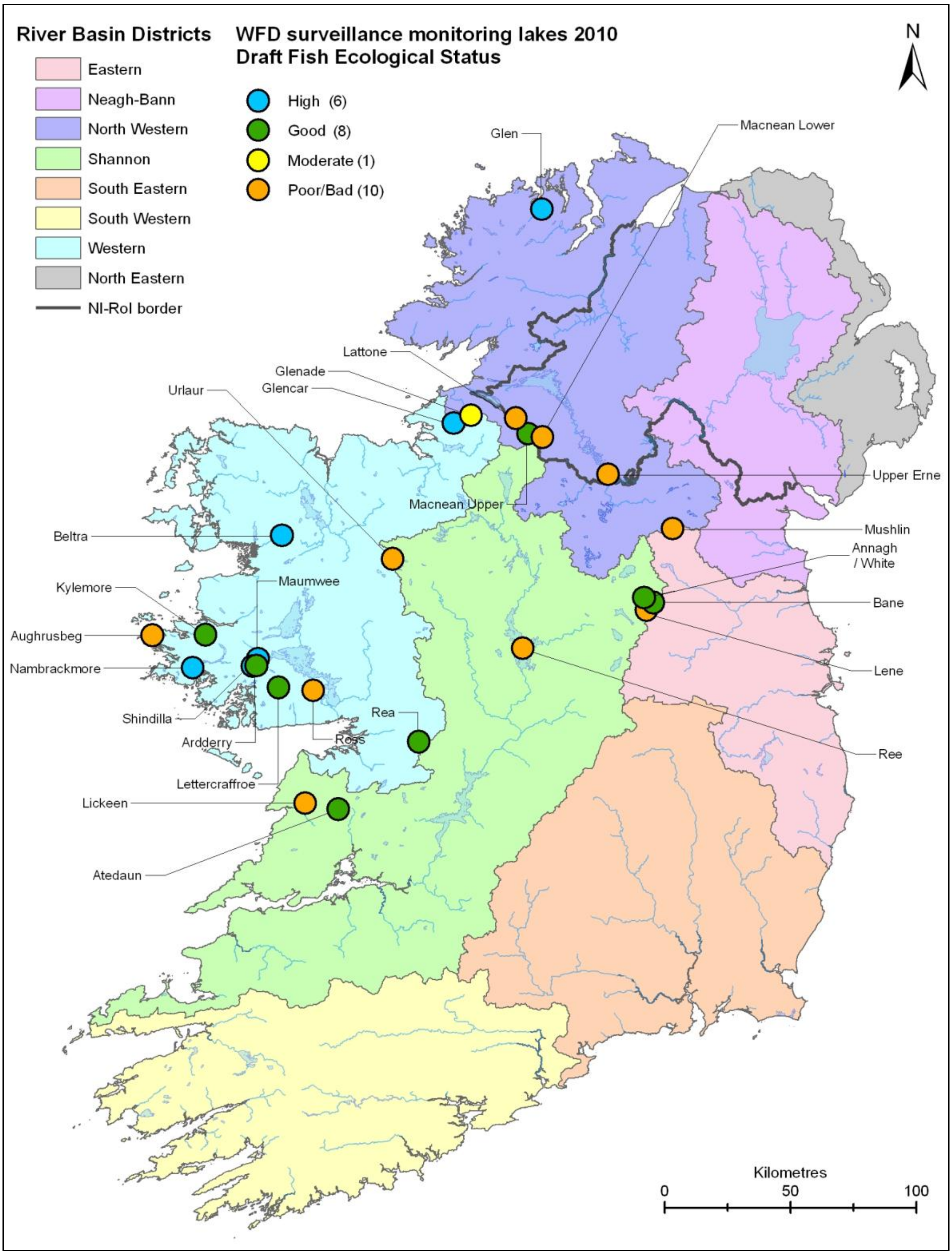

Fig. 4.44. Ecological classification of lakes surveyed during 2010 using the FIL2 ecological classification tool

4.2 Rivers

4.2.1 Fish species composition and species richness

Trout, salmon and eels are ubiquitous in Ireland and occur in practically all waters to which they are able to gain access. Irish freshwaters contain only 11 truly native fish species, comprising three salmonids, one coregonid, European eel, one shad, two sticklebacks and three lampreys (Kelly *et al*., 2007c, Champ *et al*., 2009). Three fish groups have been identified and agreed for Ecoregion 17 by a panel of fishery experts (Kelly *at al*., 2008b). These are Group 1 – native species, Group 2 – non-native species influencing ecology and Group 3 – non-native species generally not influencing ecology. In the absence of major human disturbance, a river fish community is considered to be in reference state in relation to fish if the population is dominated by salmonids or euryhaline species with an arctic marine past, i.e. native fish species (Group 1) are the only species present in the river (Kelly *et al*., 2007c). A list of fish species recorded in the 43 river sites surveyed during 2010 is shown in Table 4.5. The percentage of river sites in which each fish species occurred is shown in Figure 4.45.

Table 4.5.List of fish species recorded in the 43 river sites surveyed during 2010

	Scientific name	Common name	Number of river sites	% river sites
	NATIVE SPECIES			
1	*Salmo trutta*	Brown trout	34	79
2	*Anguilla Anguilla*	Eel	33	77
3	*Salmo salar*	Salmon	29	67
4	*Gasterosteus aculeatus*	Three-spined stickleback	21	49
5	*Lampetra* sp.	Lamprey sp.	21	49
6	*Salmo trutta*	Sea trout *	3	7
7	*Platichthys flesus*	Flounder	3	7
8	*Pungitius pungitius*	Nine-spined stickleback	1	2
	NON NATIVE (influencing ecology)			
9	*Phoxinus phoxinus*	Minnow	22	51
10	*Perca fluviatilis*	Perch	17	40
11	*Esox lucius*	Pike	16	37
12	*Rutilus rutilus*	Roach	16	37
13	*Leuciscus leuciscus*	Dace	5	12
14	*Abramis brama*	Bream	3	7
15	*Scardinius erythrophthalmus*	Rudd	2	5
	NON NATIVE SPECIES (generally not influencing ecology)			
16	*Barbatula barbatula*	Stone loach	18	42
17	*Gobio gobio*	Gudgeon	9	21
	Hybrids			
	Rutilus rutilus x *Abramis brama*	Roach x bream hybrid	2	5

*Sea trout are included as a separate "variety" of trout

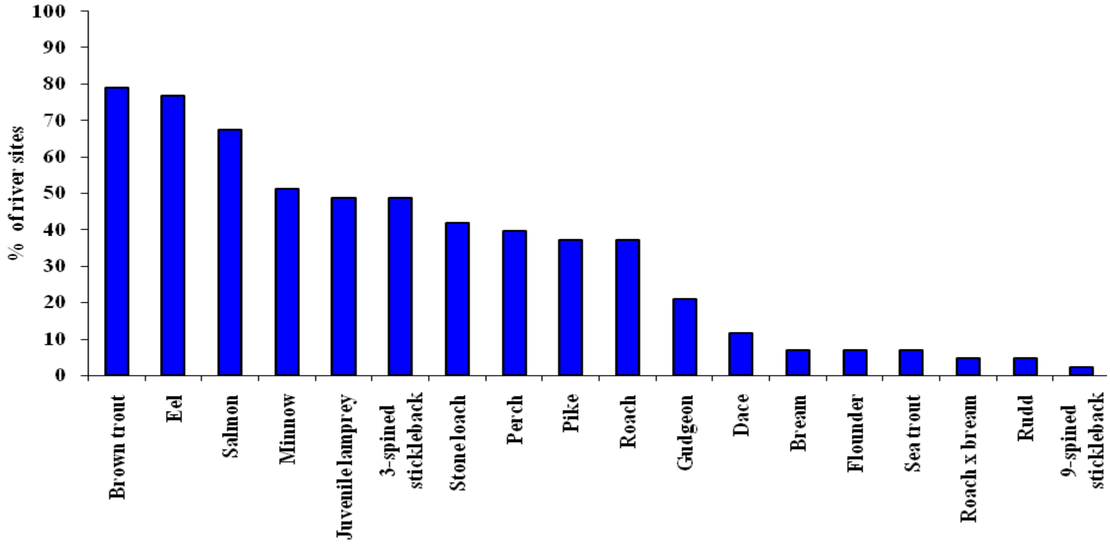

Fig. 4.45. Percentage of sites where each fish species was recorded (total of 43 river sites surveyed) during WFD surveillance monitoring 2010

A total of 17 fish species (sea trout are included as a separate "variety" of trout) and one type of hybrid were recorded in the 43 river sites surveyed during 2010. Brown trout was the most widespread species occurring in 79% of the sites surveyed, followed by eels (77%), salmon (67%), minnow (51%), juvenile lamprey (49%), 3-spined stickleback (49%), stone loach (42%), perch (40%), pike (37%), roach (37%), gudgeon (21%) and Dace (12%). Bream, flounder, sea trout, roach/bream hybrids, rudd and 9-spined stickleback were present in less than 10% of the river sites surveyed (Table 4.5 and Fig. 4.45).

Fish species richness (excluding hybrids) ranged from one species at one river site (Screeb River in the WRBD) to a maximum of ten species in the River Blackwater at Lismore (SWRBD) (Table 4.6 and Figs. 4.46 and 4.47). Native species were present in nearly all of the sites surveyed except for the two Shannon River sites at Battle Bridge (ShIRBD) and the Screeb River in the WRBD. Only four out of a total of 43 sites contained exclusively native species. The maximum number of native species captured in any site was five and this was recorded in eight sites (Table 4.6). Group 2 species (non native species influencing ecology) were present at 37 sites. The maximum number of non-native species recorded at any one site was six species, recorded in both the River Lee at Inchinossig Bridge and the River Shannon at Lanesborough (Site A). Only one Group 3 species (gudgeon) was present in the river sites surveyed, being recorded at nine sites.

Table 4.6. Species richness in each river site surveyed for WFD fish monitoring 2010

River	RBD	Species richness	No. native species (Group 1)	No. non-native species (Group 2)	No. non-native species (Group 3)
Wadeablesites					
Lee (Inchinossig)	SWRBD	9	3	5	1
Cullies	NWIRBD	8	3	4	1
Gowran	SERBD	6	5	1	0
Moy (Cloonbaniff)	WRBD	5	2	3	0
Dalua	SWRBD	5	4	1	0
Slaney	SERBD	5	4	1	0
Fane	NBIRBD	5	4	1	0
Abbert	WRBD	4	3	1	0
Finisk	SWRBD	4	4	0	0
Owenreagh	SWRBD	4	3	1	0
Cummeragh	SWRBD	5*	5*	0	0
Owenriff	WRBD	3	2	1	0
Licky	SWRBD	3	3	0	0
Avonbeg	ERBD	3	3	0	0
Non-wadeable sites					
Blackwater (Lismore)	SWRBD	10	5	4	1
Bonet	WRBD	9	5	3	1
Ballysadare	WRBD	9	5	4	0
Suir (Kilsheelan)	SERBD	9	5	4	0
Clare (Kiltrogue)	WRBD	8	5	3	0
Clare (Corrofin)	WRBD	8	4	4	0
Moy (Bleanmore)	WRBD	8	4	4	0
Lee (Leemount Br.)	SWRBD	8	4	3	1
Funshion	SWRBD	8	5	3	0
Shannon (Lanesborough A)	SHIRBD	8	2	5	1
Moy (Gweestion)	WRBD	8*	5*	3	0
Blackwater (Nohaval)	SWRBD	7	5	2	0
Shannon (Lanesborough B)	SHIRBD	7	2	5	0
Suir (Knocknageragh)	SERBD	7	5	2	0
Nore (Quaker's)	SERBD	7	3	3	1
Nore (Brownsbarn)	SERBD	7	4	3	0
Owenmore (Sligo)	WRBD	6	3	3	0
Ballydangan	SHIRBD	6	2	3	1
Shannon (Clonmacnoise)	SHIRBD	5	2	3	0
Barrow	SERBD	5	1	4	0
Ara	SERBD	5	4	1	0
Aherlow	SERBD	5	3	2	0
Robe	WRBD	4	2	2	0
Owvane (Cork)	SWRBD	5*	4*	1	0
Shannon (Battle B)	SHIRBD	4	0	3	1
Shannon (Athlone)	SHIRBD	4	1	3	0
Shannon (Battle A)	SHIRBD	3	0	3	0
Boyne	ERBD	3	1	2	0
Screeb	WRBD	1	0	1	0

* Sea trout are included as a separate "variety"of trout

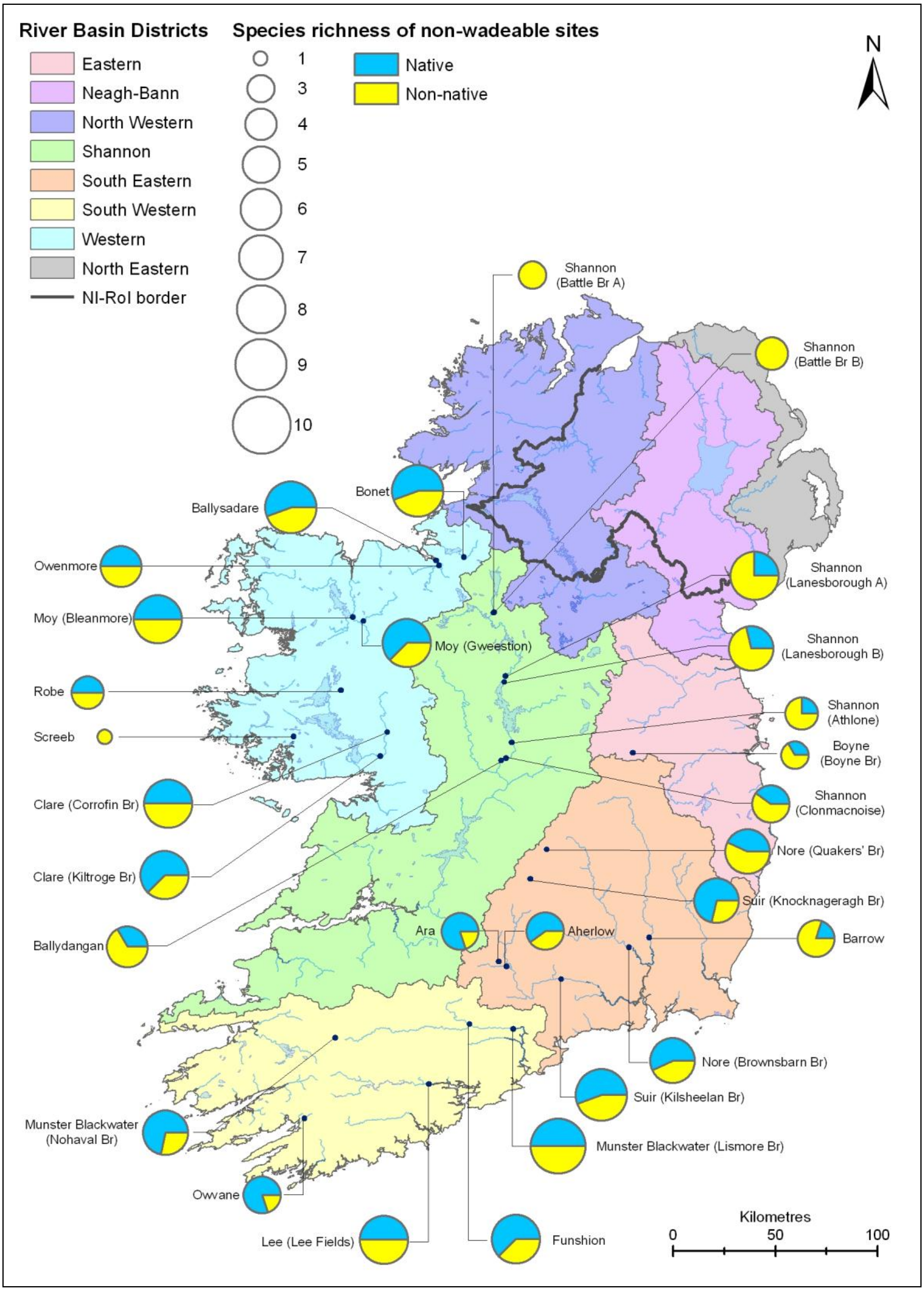

Fig. 4.46. Fish species richness at non-wadeable river sites surveyed using boat based electric-fishing equipment for WFD fish monitoring 2010

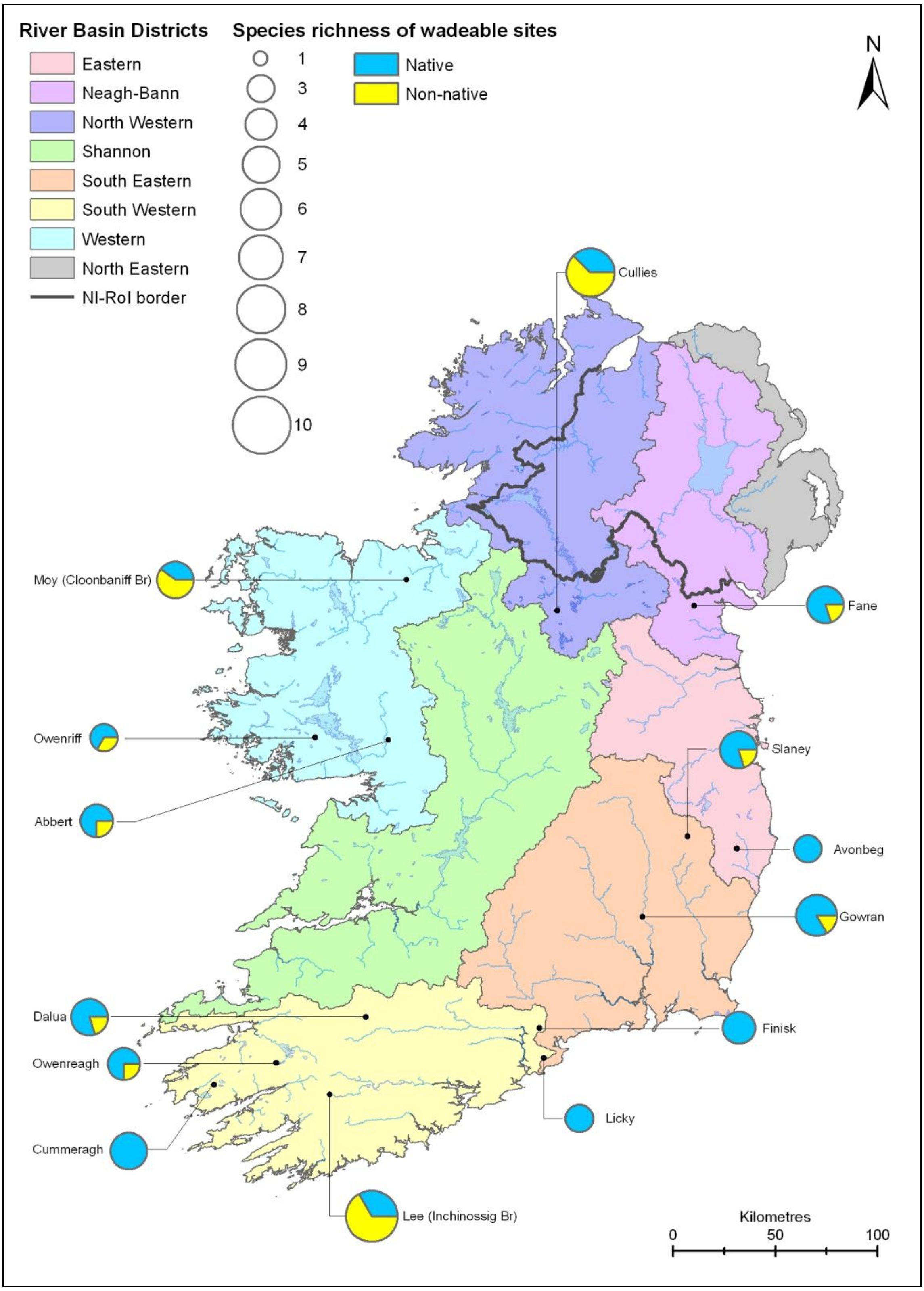

Fig. 4.47.Fish species richness at wadeable river sites surveyed using handset electric-fishing equipment for WFD fish monitoring 2010

4.2.2 Fish species distribution and abundance

Figures 4.48 to 4.79 show the distribution and abundance of each fish species from the 43 river sites surveyed during 2010. The fish population density represented in the figures is based on the first fishing in which each species was encountered at each site and is expressed as the number of fish per m^2 ('minimum estimate').

Brown trout were the most widely distributed species among sites surveyed in 2010 (Fig. 4.48 to Fig. 4.51), being recorded in 34 of the 42 sites. Brown trout fry (0+) were present in 19 sites (Fig. 4.48 and Fig. 4.49), while older fish (1+ and older) were encountered in 33 sites (Fig. 4.50 and Fig. 4.51). Brown trout fry (0+) densities were consistently higher in the wadeable streams than in the non-wadeable deeper channels where boat based electric-fishing was used to carry out the survey. In rivers surveyed with boat based electric-fishing equipment, the highest density of fry (0.06 fish/m^2) was captured in the Owenmore River site within the WRBD and the highest density of 1+ and older fish were recorded in the River Suir at Knocknageragh Bridge (SRBD) (0.13 fish/m^2). In the wadeable streams, the highest densities of fry (0.14 fish/m^2) and 1+ and older fish(0.12 fish/m^2) were recorded in the Cummeragh River site (SWRBD) and Ara River site (SRBD) respectively.

Sea trout, as expected, were only recorded in sites close to the coast and in rivers that allow upstream access; the Owvane and Cummeragh Rivers in the SWRBD and the River Moy (Gweestion) in the WRBD (Fig. 4.52 and Fig. 4.53). The highest density of sea trout (although still relatively low when compared with other species) was recorded in the Cummeragh River site (<0.01 fish/m^2).

Salmon were also widely distributed throughout the country, being present in 29 sites. Salmon fry (0+) were captured in 25sites (Fig. 4.54 and Fig. 4.55), while older salmon (1+ & older) were recorded in 28 sites (Fig. 4.56 and Fig. 4.57). In a similar trend to that of brown trout, salmon fry (0+) densities were generally higher in the shallow wadeable streams than in non-wadeable deeper channels sampled with boat based electric-fishing equipment. For the sites sampled using boat based electric-fishing equipment, the highest density of fry (0.05 fish/m^2) was recorded in the Owenmore River site (WRBD) whilst the highest density of 1+ and older fish was captured in the River Blackwater at Nohaval Br. (0.03 fish/m^2). Among the wadeable streams, the highest densities of fry (0.47 fish/m^2) and 1+ and older fish (0.27 fish/m^2) were recorded in the Cummeragh River site (SWRBD) and Fane River site (NBIRBD) respectively.

Eels were present in 33 sites, and their distribution is shown in Fig. 4.58 and Fig. 4.59. Eel densities were generally higher in wadeable streams and in sites closest to the sea. The greatest eel density (0.05 fish/m^2) was recorded within the SRBD, in the Gowran River site.

Flounder were recorded in three sites; the River Suir at Kilsheelan and River Nore at Brownsbarn (SERBD) and River Blackwater at Lismore (SWRBD), all of which are located close to the sea (Fig.

4.60 and Fig. 4.61). Only three rivers had flounder recorded in them, with the highest density recorded in the River Nore at Brownsbarn Br. (<0.01 fish/m^2).

Three-spined stickleback were distributed throughout the country (Fig. 4.62 and Fig. 4.63), being captured in 21 sites. Their highest density (0.15 fish/m^2) was recorded in the Cummeragh River site within the SWRBD.

Juvenile lamprey were recorded in 21 river sites (Fig. 4.64 and Fig. 4.65), of which the River Lee (Inchinossig Br.) within the SWRBD had the highest density (<0.02 fish/m^2). Stone loach were more prevalent in the southern half of the country (Fig. 4.66 and Fig. 4.67), with the greatest density (0.13 fish/m^2) recorded in the Gowran River site (SRBD). Minnow were generally more abundant in the north western and southern parts of the country (Fig. 4.68 and Fig. 4.69), with their greatest density (0.16 fish/m^2) being recorded in the River Moy at Cloonbaniff Br. (WRBD).

Roach (Fig. 4.70 and Fig. 4.71) were generally more prevalent in the deeper sites surveyed using boat based electric-fishing equipment and were distributed mainly in the north western half of the country and the midlands, particularly in the WRBD and northern half of the SHIRBD. The greatest density of roach was 0.47 fish/m^2, recorded in the Cullies River site in the NWIRBD.

Perch were recorded in 17 sites (Fig. 4.72 and Fig. 4.73), sharing a very similar distribution to that of roach, being more prevalent in the north west of the country and the midlands (WRBD & SHIRBD). Perch were mostly recorded in the SHIRBD; however, their highest density was recorded in the Cullies River within the NWIRBD (0.44 fish/m^2).

Pike (Fig. 4.74 and Fig. 4.75) were captured at 16 river sites during 2010. The Cullies River site within the NWIRBD exhibited the highest density of pike (<0.01 fish/m^2), although this was relatively small when compared to most other species captured.

Gudgeon (Fig. 4.76 and Fig. 4.77) were recorded throughout the country, in four different river basin districts, the SHIRBD, SERBD, SWRBD and WRBD. The highest recorded density of gudgeon (0.04 fish/m^2) was observed in the Bonet River site within the WRBD.

Dace, a non-native invasive fish species, were recorded in five sites during 2010 (Fig. 4.78 and Fig. 4.79). Within the SERBD, they were recorded in the River Barrow at Graiguenamanagh, River Nore at Brownsbarn Br. and River Suir at Kilsheelan Br., all of which are connected to each other. In the SWRBD they were encountered in another two connected rivers, the River Blackwater at Lismore and River Funshion. Overall densities for dace were low compared with other species with the highest density recorded in the River Funshion (<0.01fish/m^2).

A number of other fish species were only encountered in a few locations. Nine-spined stickleback were captured in the Clare River at Corrofin (WRBD), bream and rudd in the Upper River Shannon at

Ballyleague (Site A and B) (SHIRBD), and roach x bream hybrids in both the Upper River Shannon at Ballyleague (Site B) and Cullies River (NRFB).

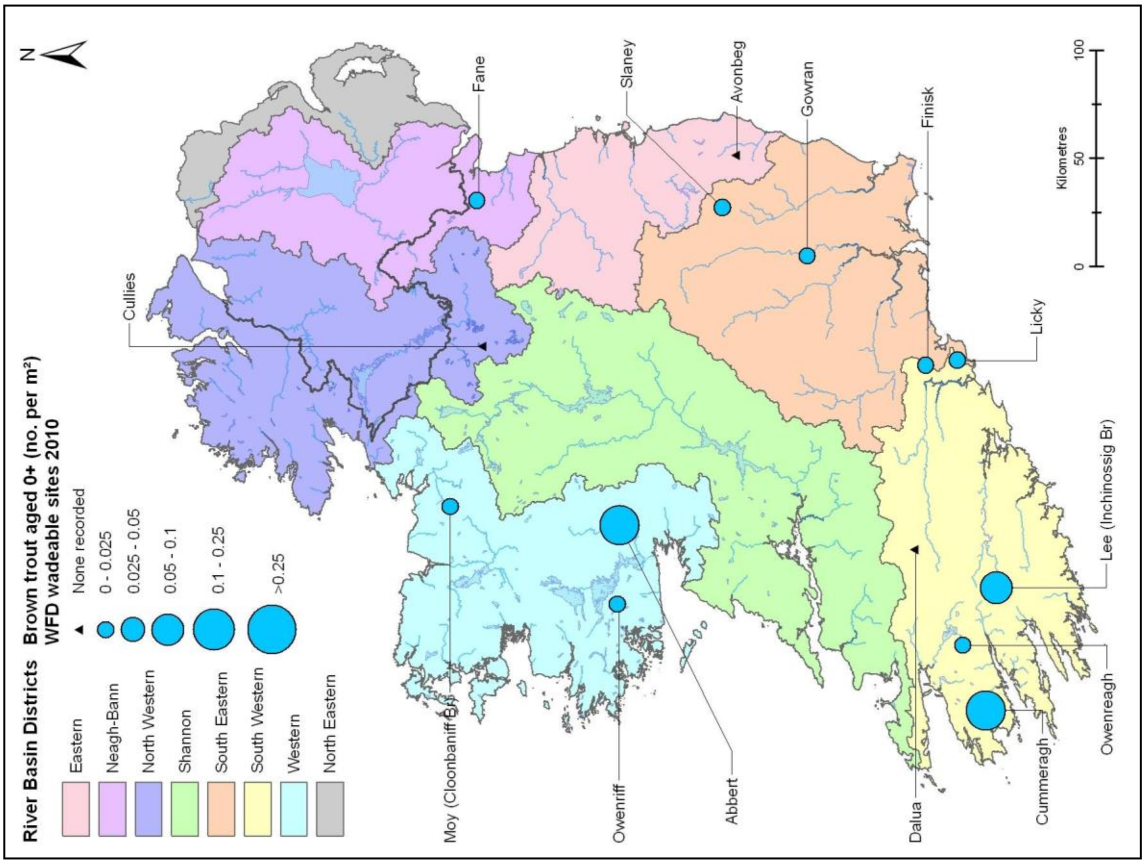

Fig. 4.48. Distribution and abundance of 0+ brown trout at wadeable river sites surveyed for WFD fish monitoring 2010

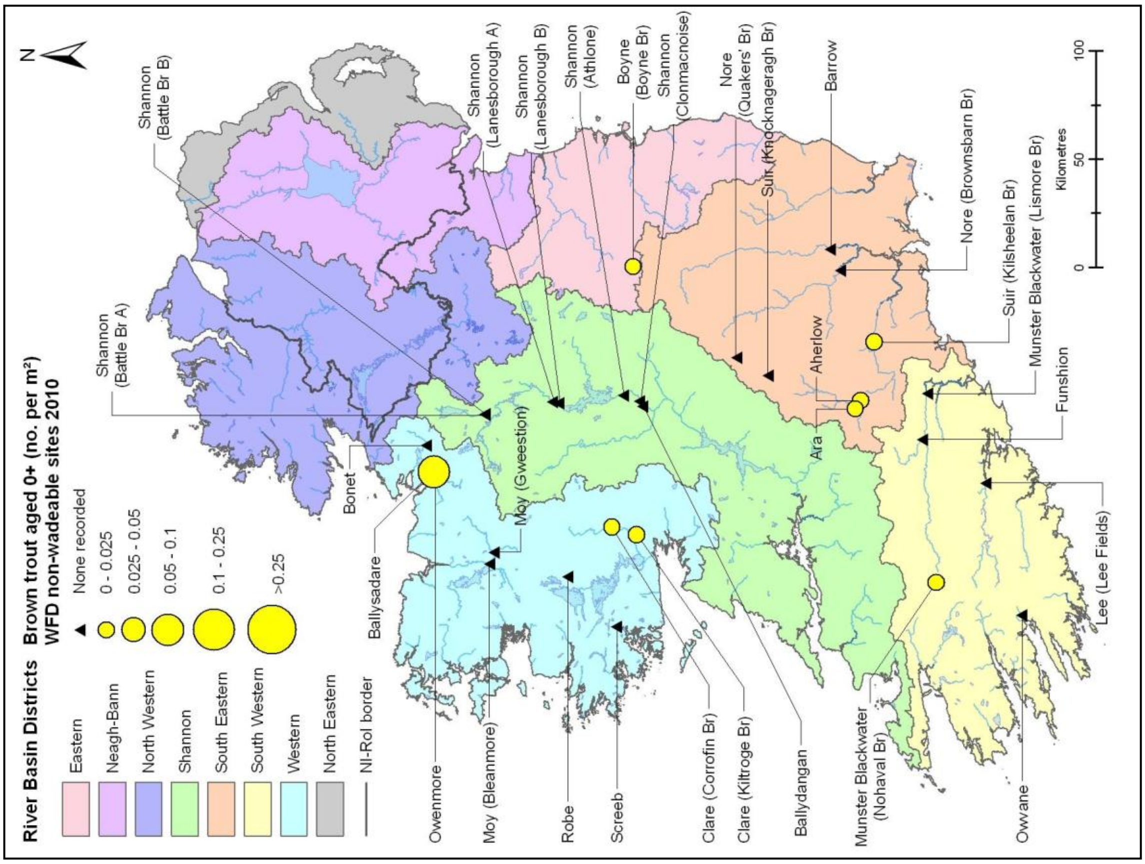

Fig. 4.49. Distribution and abundance of 0+ brown trout at non-wadeable river sites surveyed for WFD fish monitoring 2010

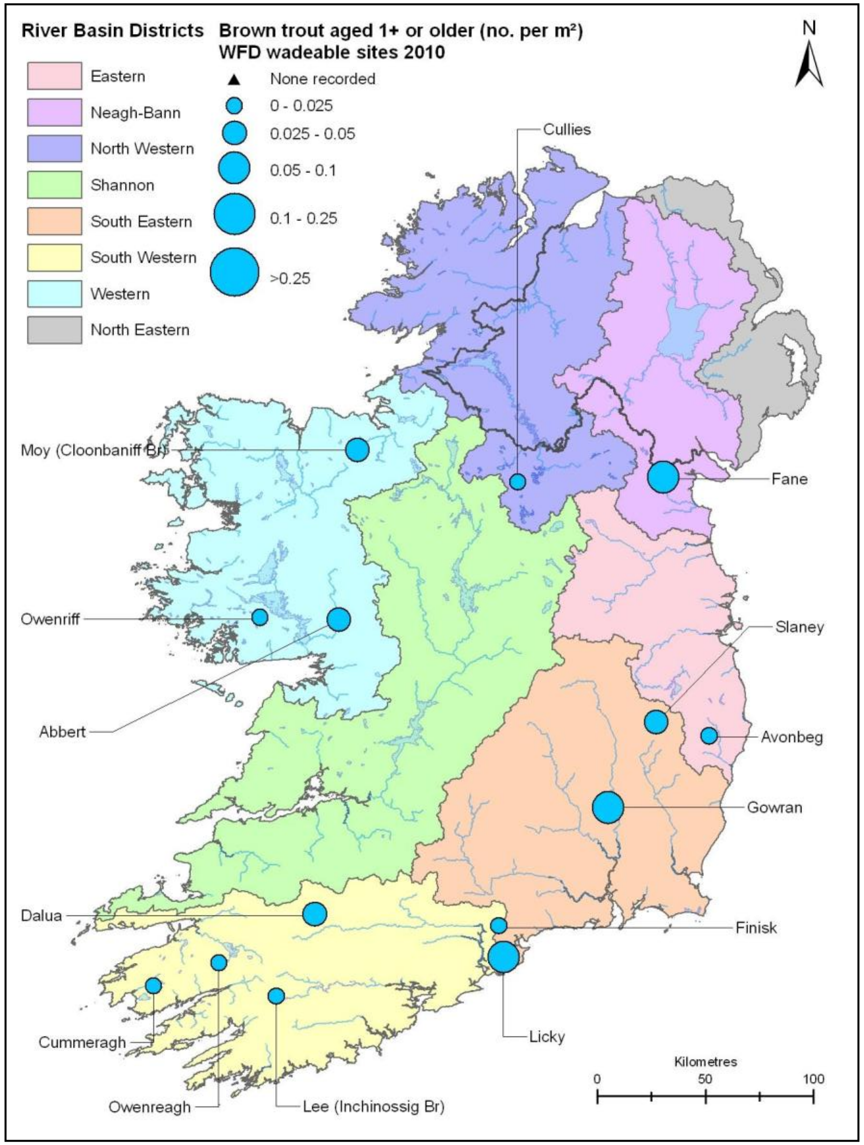

Fig. 4.50. Distribution and abundance of 1+ brown trout at wadeable river sites surveyed for WFD fish monitoring 2010

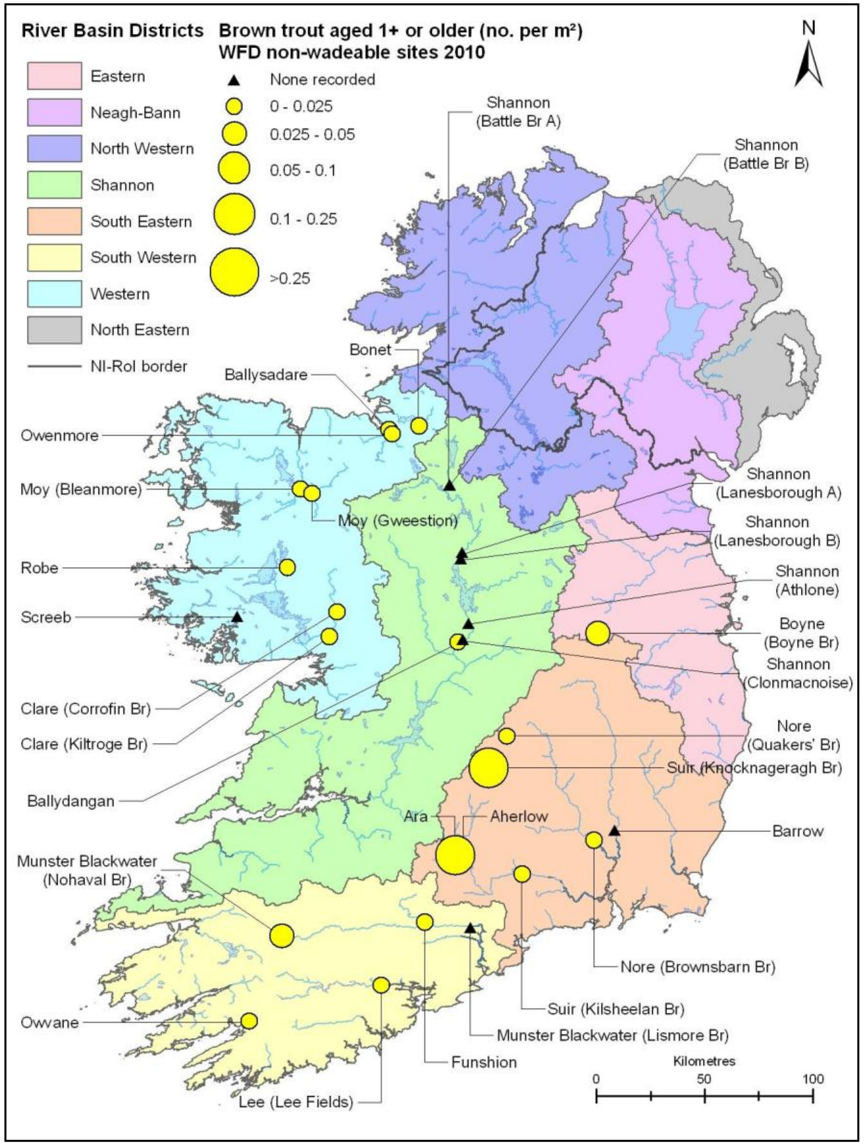

Fig. 4.51. Distribution and abundance of 1+ brown trout at non-wadeable river sites surveyed for WFD fish monitoring 2010

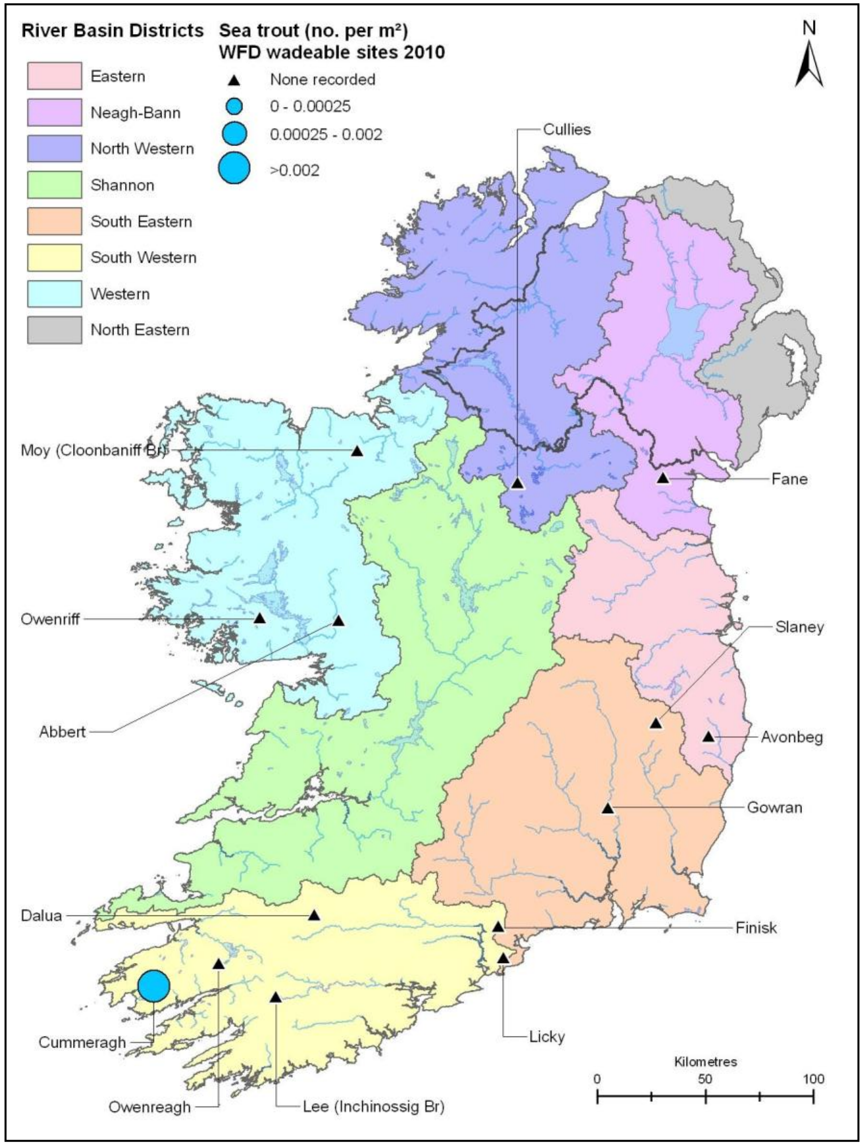

Fig. 4.52. Distribution and abundance of sea trout at wadeable river sites surveyed for WFD fish monitoring 2010

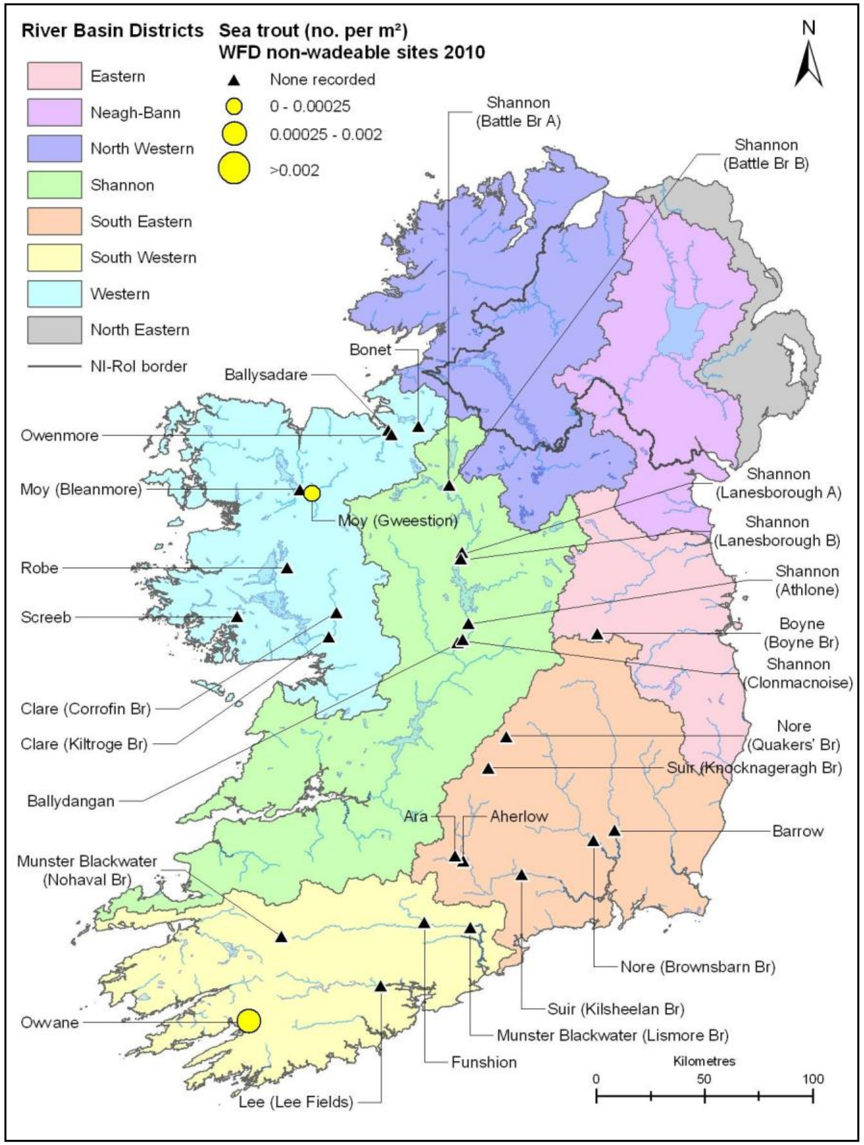

Fig. 4.53. Distribution and abundance of sea trout at non-wadeable river sites surveyed for WFD fish monitoring 2010

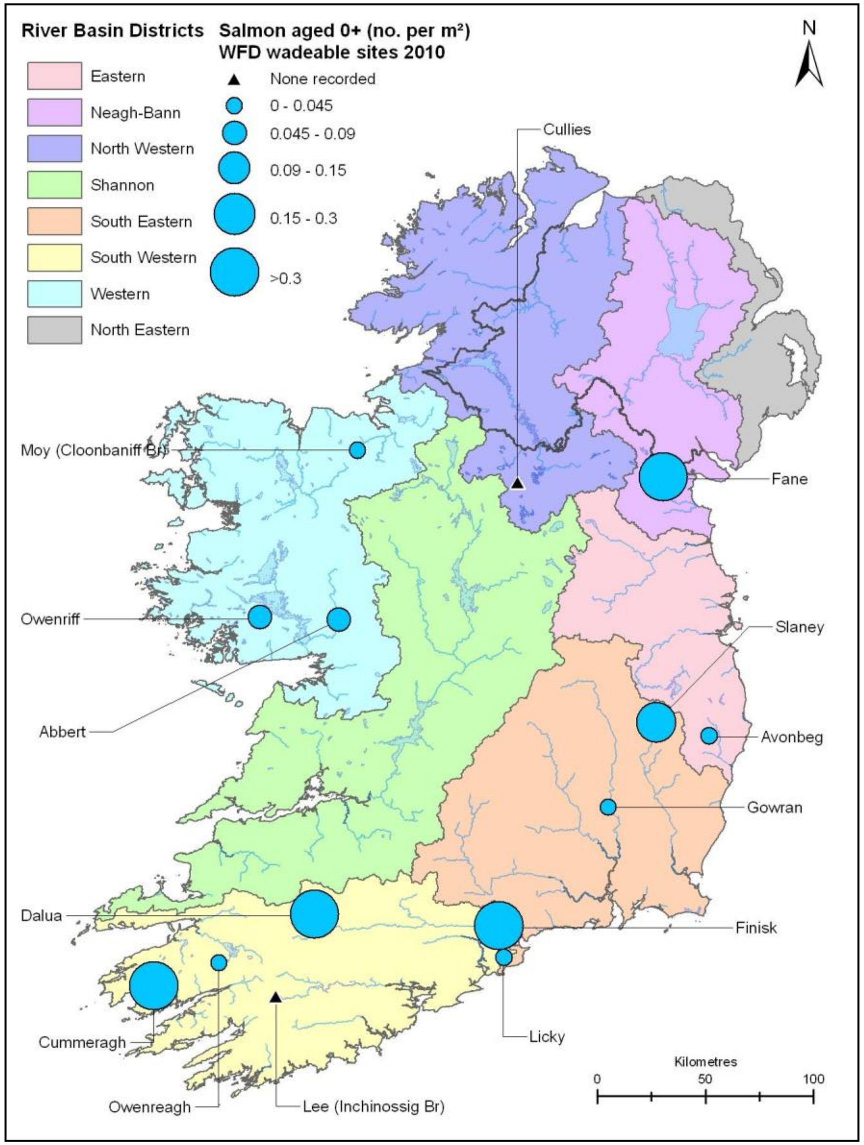

Fig. 4.54. Distribution and abundance of 0+ salmon at wadeable river sites surveyed for WFD fish monitoring 2010

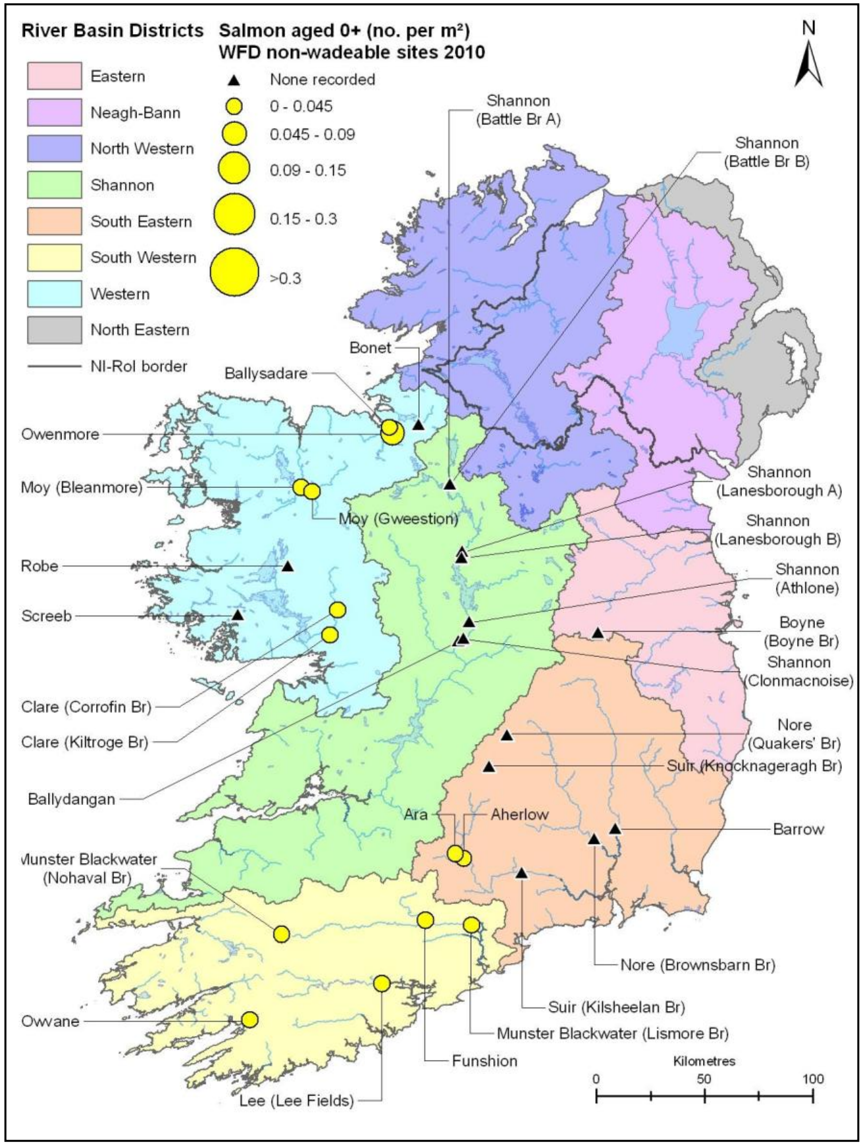

Fig. 4.55. Distribution and abundance of 0+ salmon at non-wadeable river sites surveyed for WFD fish monitoring 2010

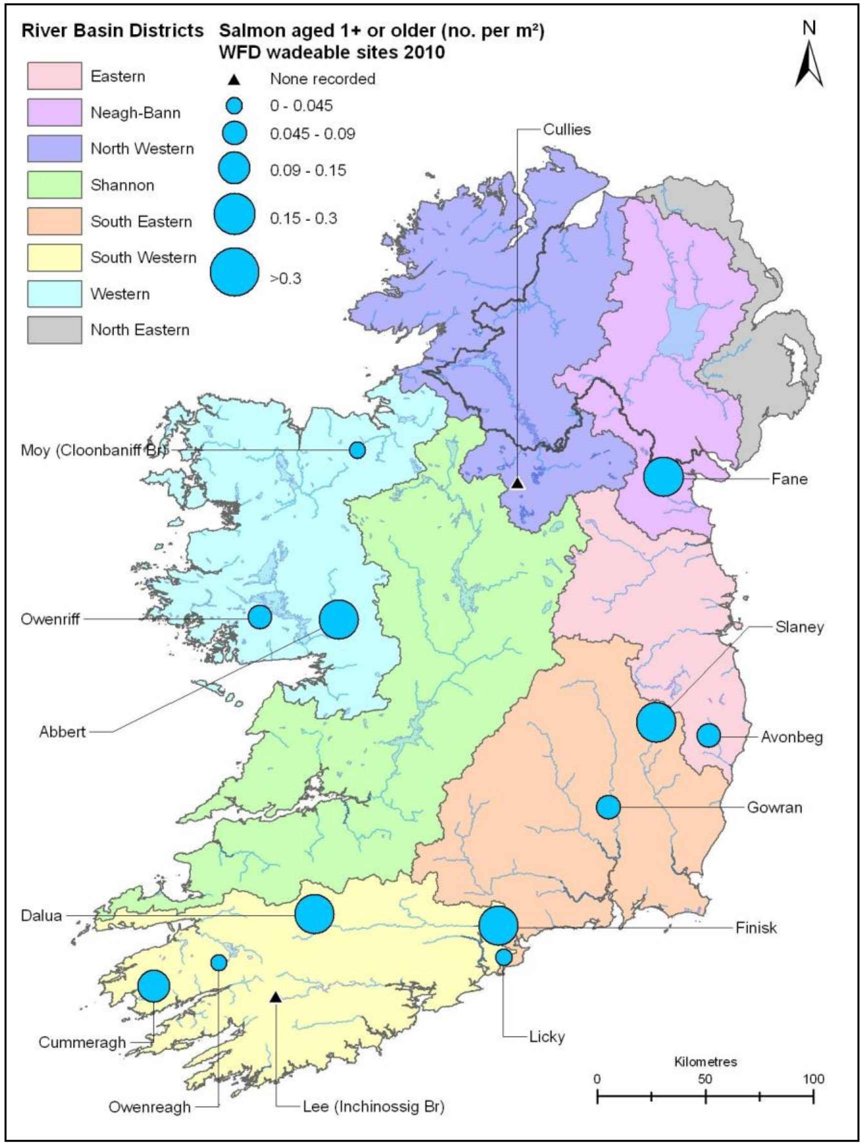

Fig. 4.56. Distribution and abundance of 1+ salmon at wadeable river sites surveyed for WFD fish monitoring 2010

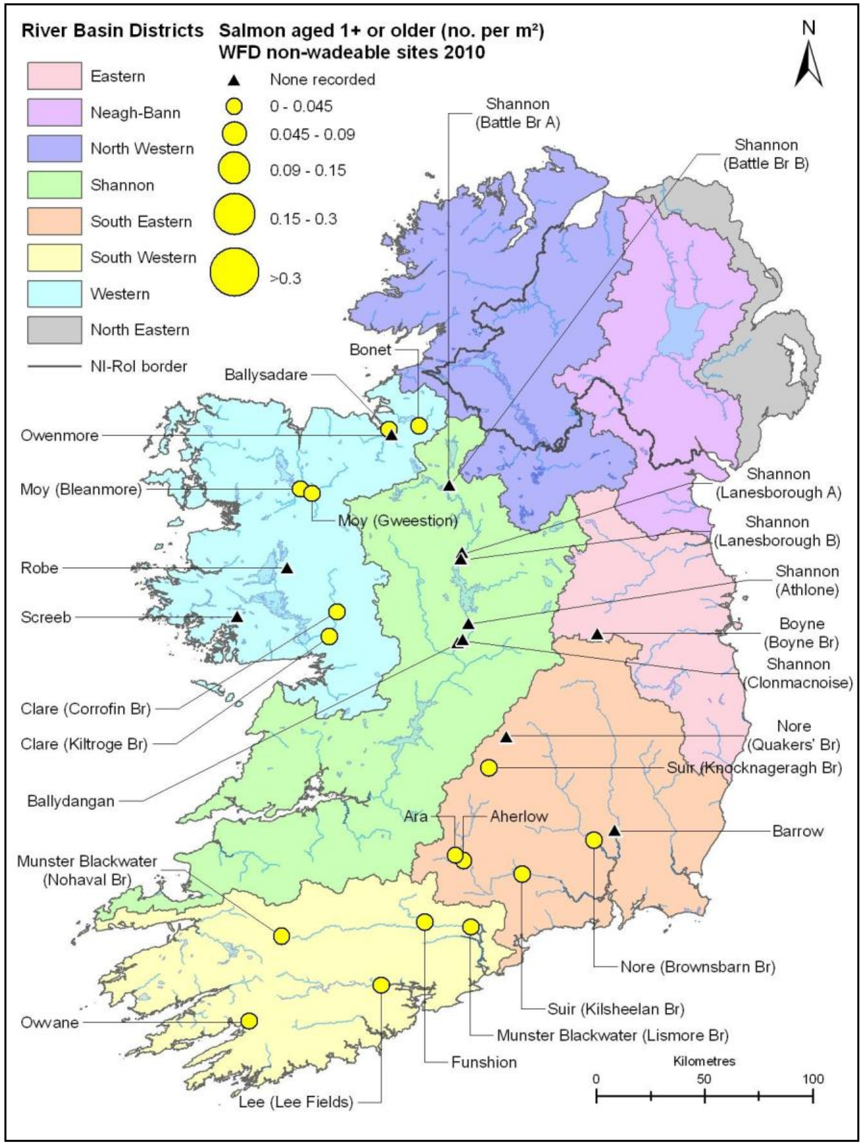

Fig. 4.57. Distribution and abundance of 1+ salmon at non-wadeable river sites surveyed for WFD fish monitoring 2010

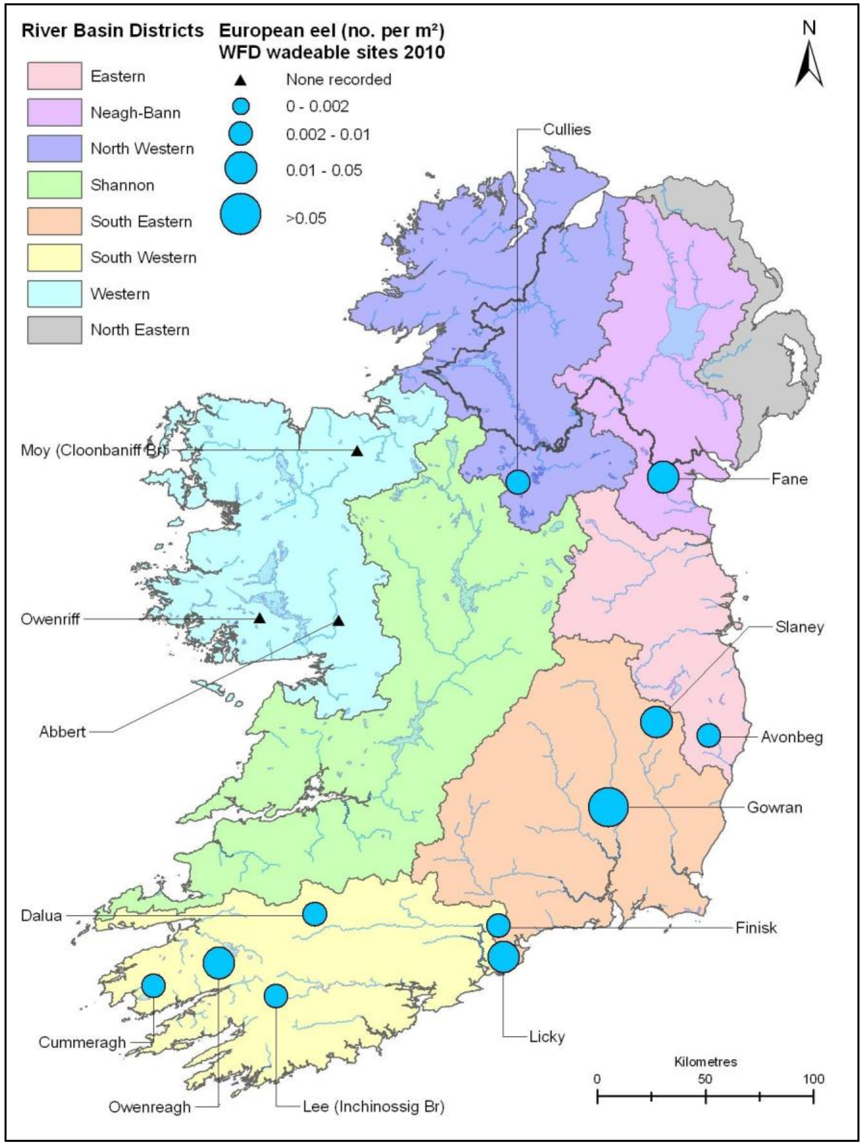

Fig. 4.58. Distribution and abundance of European eel at wadeable river sites surveyed for WFD fish monitoring 2010

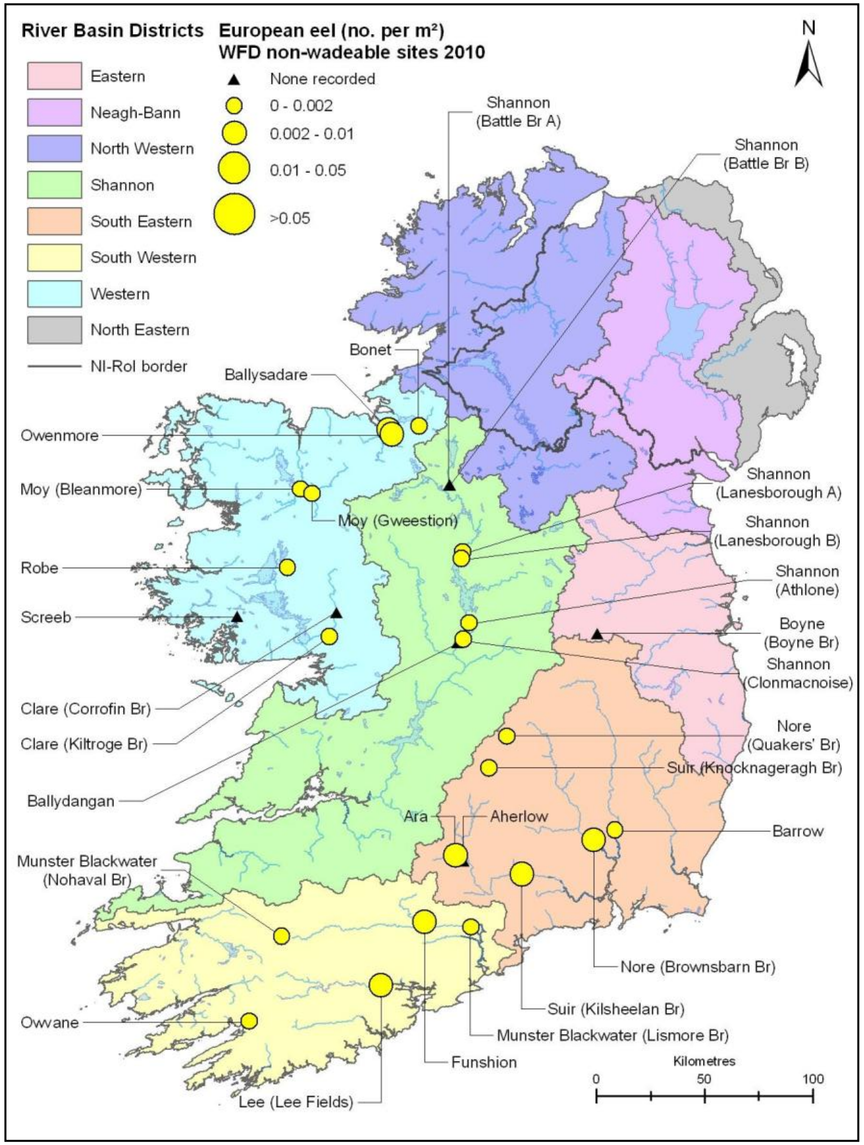

Fig. 4.59. Distribution and abundance of European eel at non-wadeable river sites surveyed for WFD fish monitoring 2010

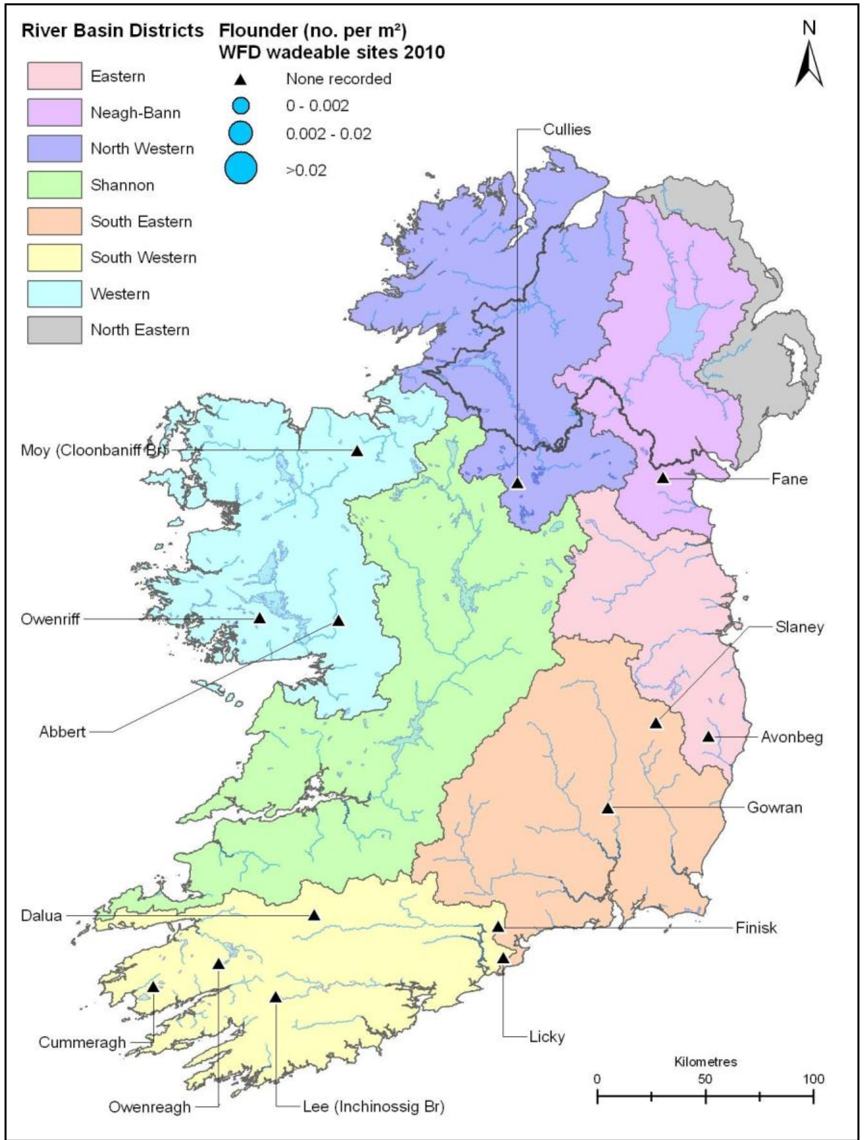

Fig. 4.60. Distribution and abundance of flounder at wadeable river sites surveyed for WFD fish monitoring 2010

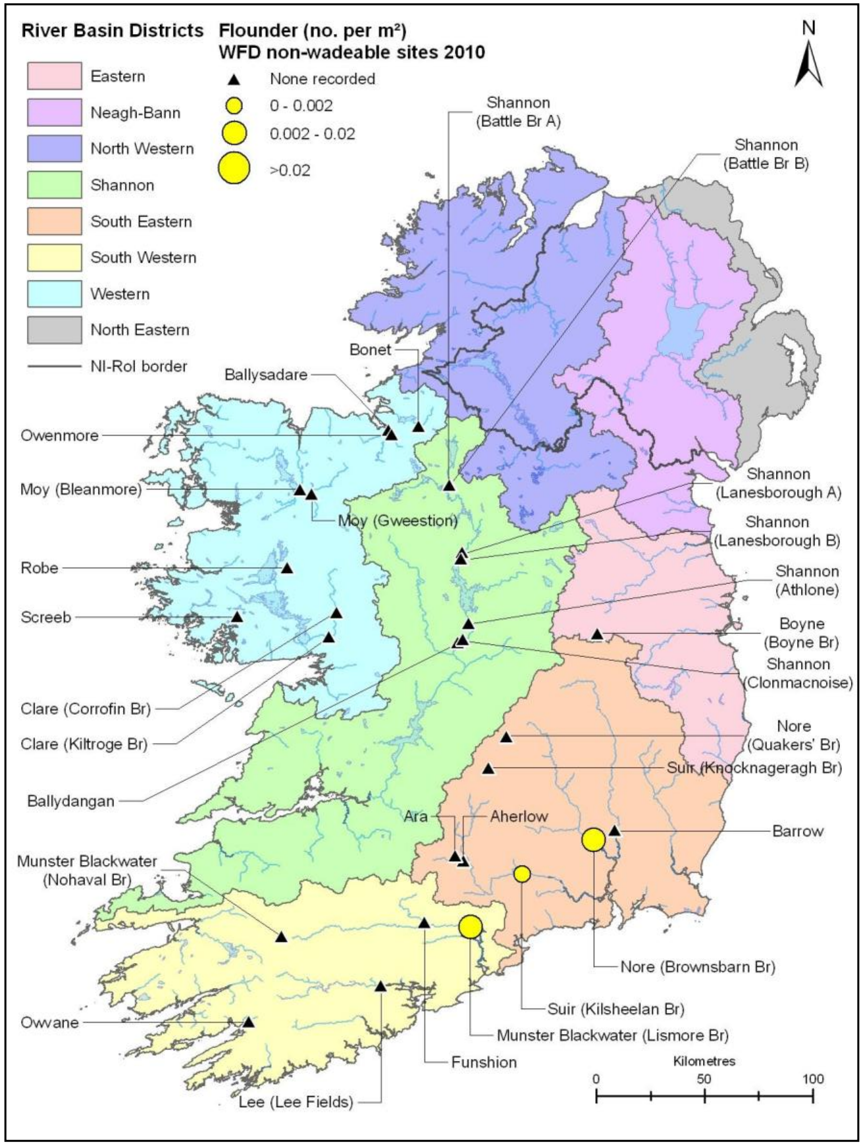

Fig. 4.61. Distribution and abundance of flounder at non-wadeable river sites surveyed for WFD fish monitoring 2010

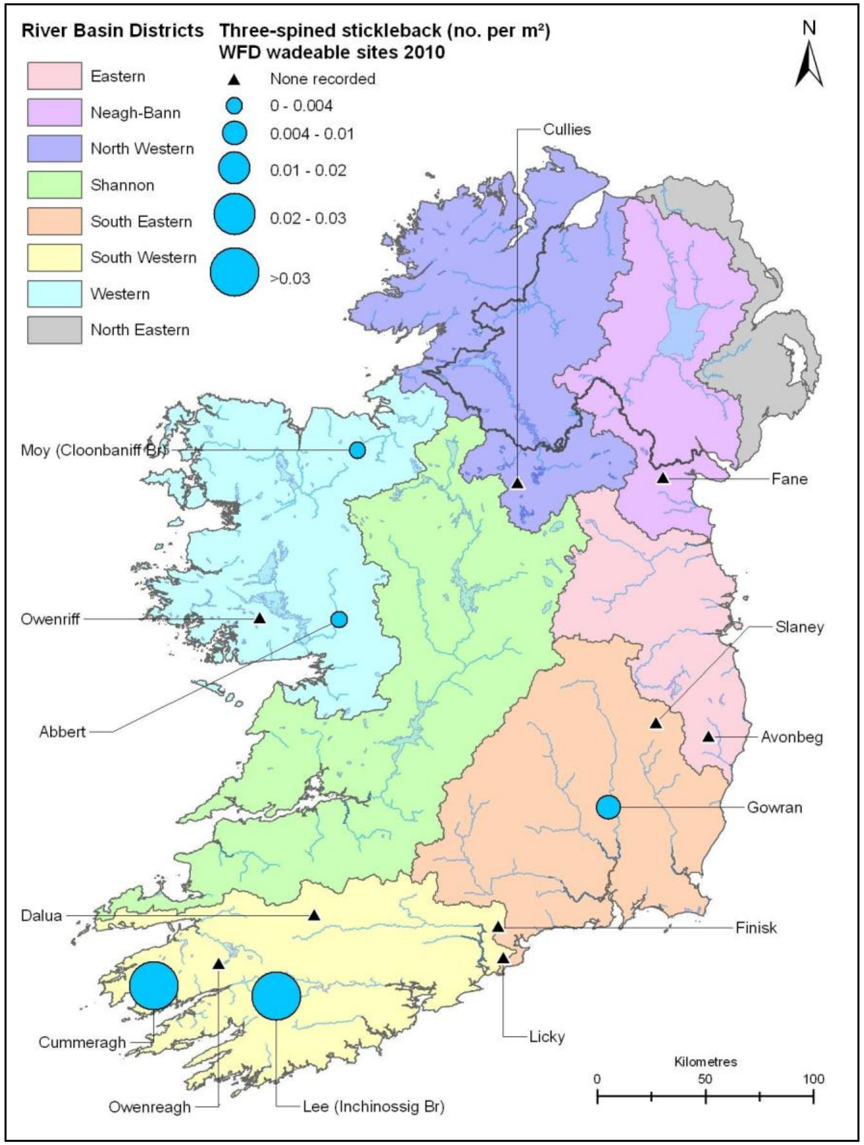

Fig. 4.62. Distribution and abundance of 3-sp stickleback at wadeable river sites surveyed for WFD fish monitoring 2010

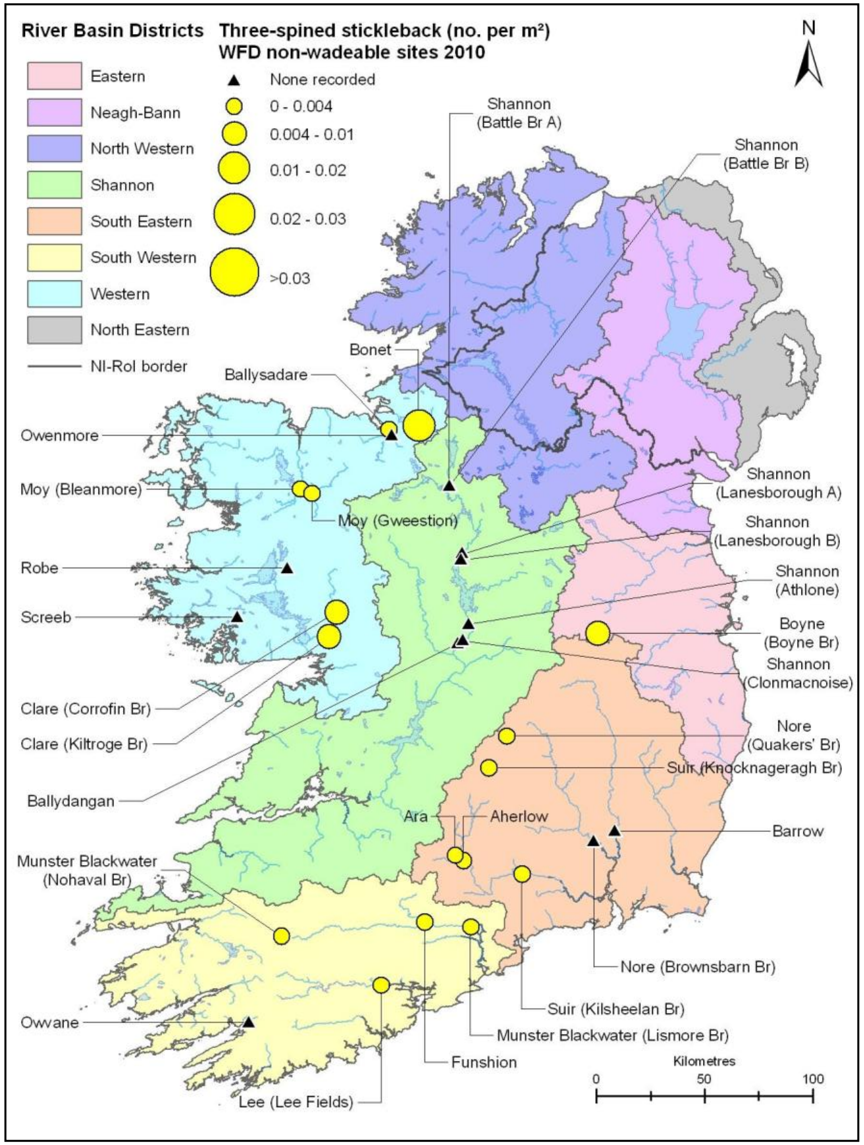

Fig. 4.63. Distribution and abundance of 3-sp stickleback at non-wadeable river sites surveyed for WFD fish monitoring 2010

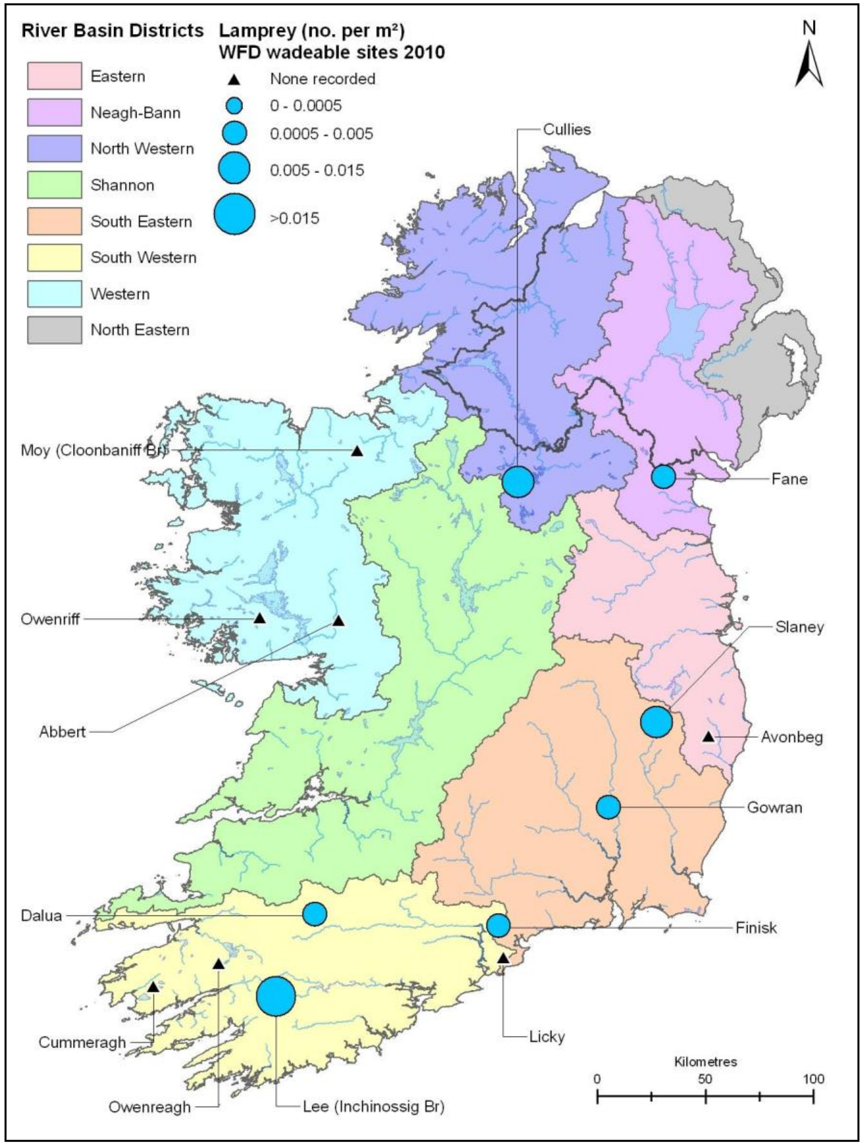

Fig. 4.64. Distribution and abundance of lamprey at wadeable river sites surveyed for WFD fish monitoring 2010

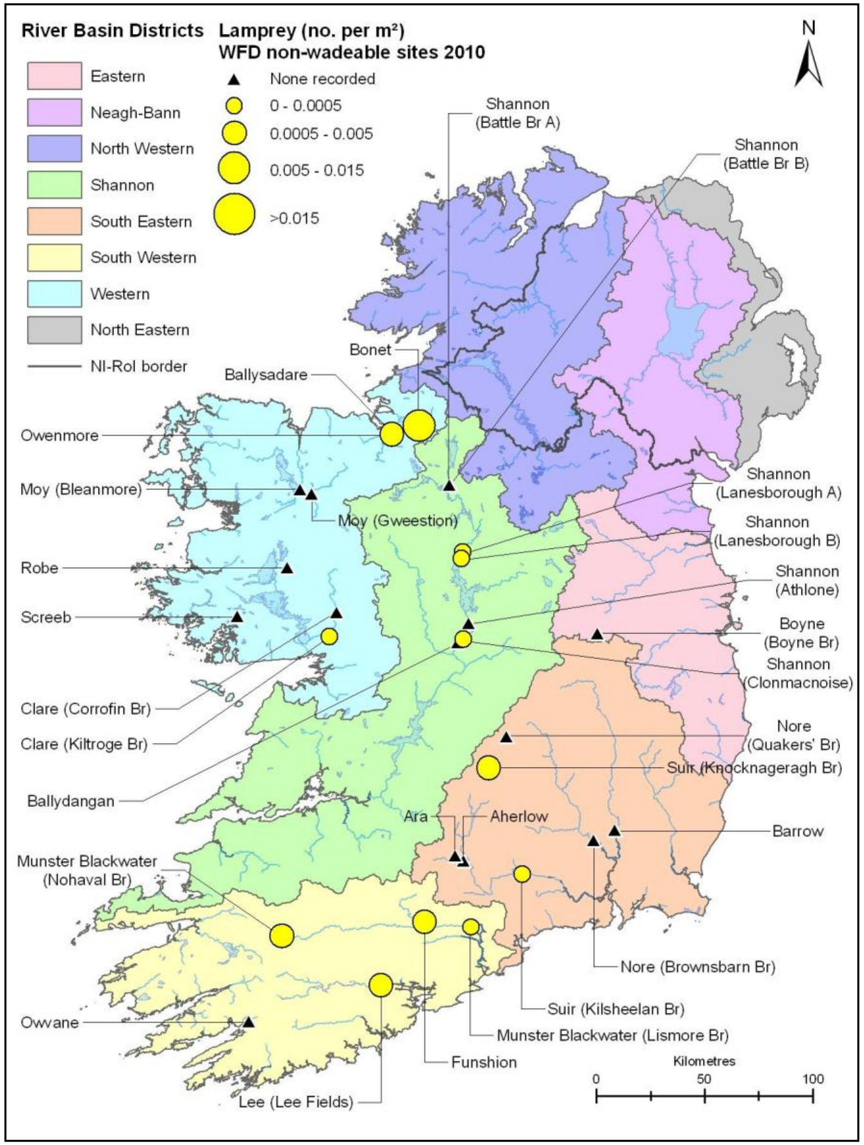

Fig. 4.65. Distribution and abundance of lamprey at non-wadeable river sites surveyed for WFD fish monitoring 2010

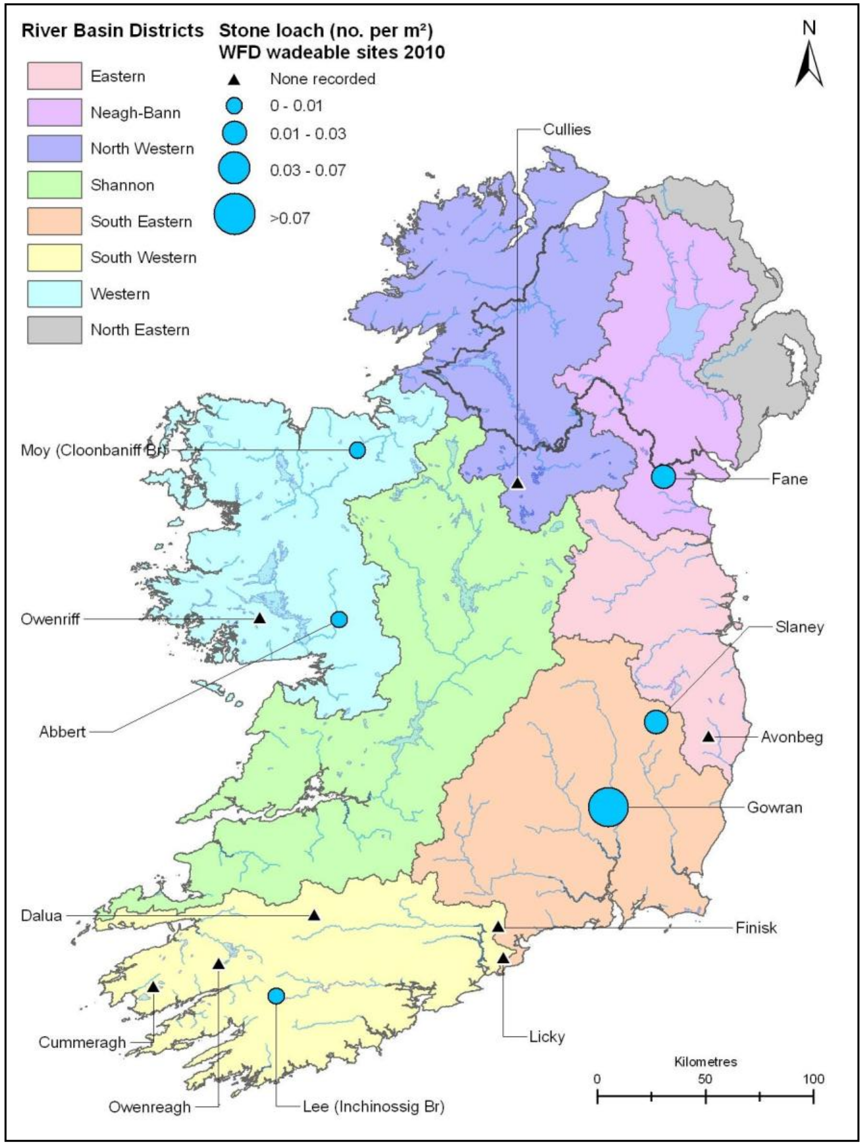

Fig. 4.66. Distribution and abundance of stone loach at wadeable river sites surveyed for WFD fish monitoring 2010

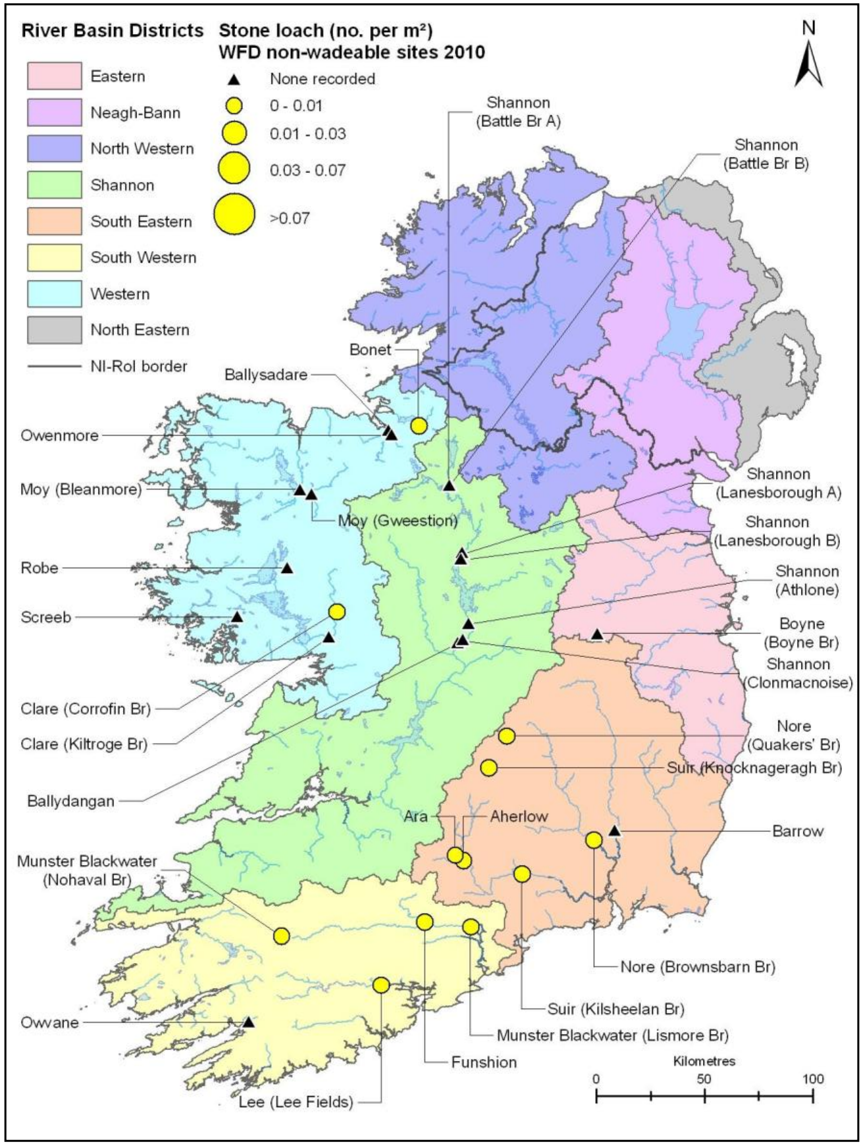

Fig. 4.67. Distribution and abundance of stone loach at non-wadeable river sites surveyed for WFD fish monitoring 2010

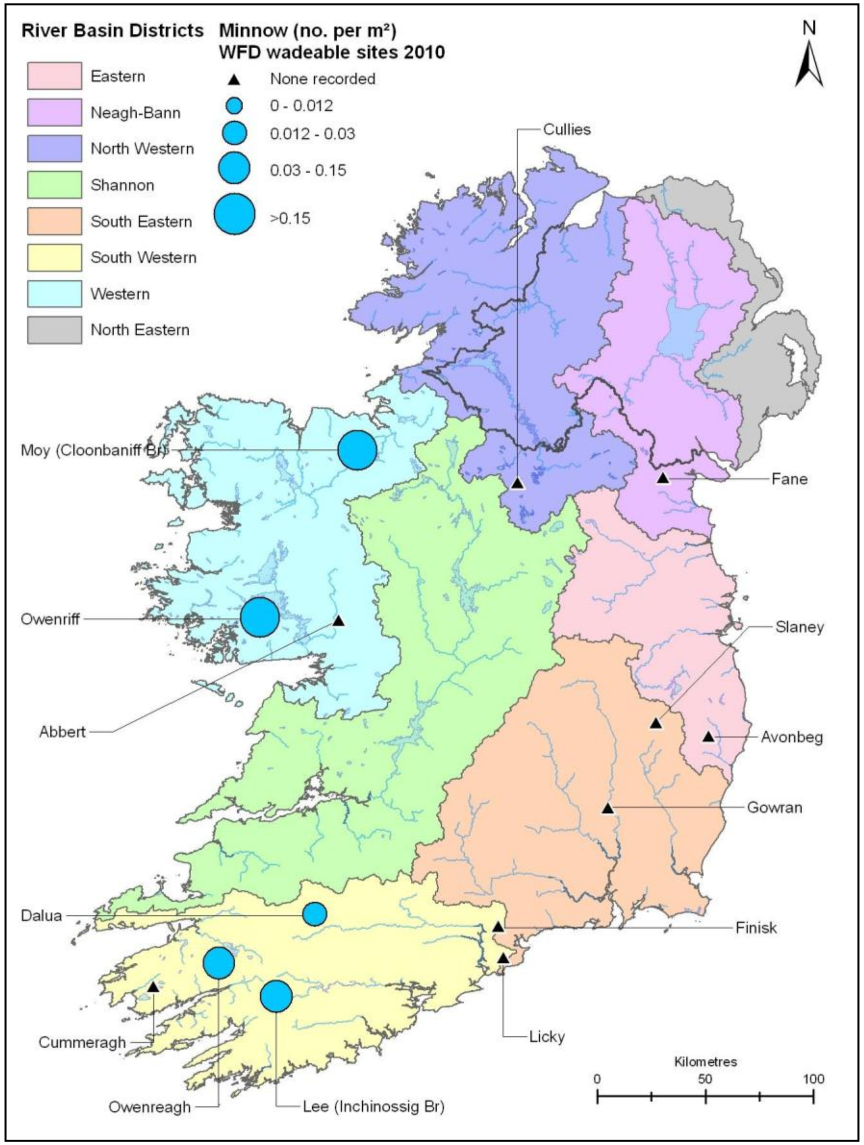

Fig. 4.68. Distribution and abundance of minnow at wadeable river sites surveyed for WFD fish monitoring 2010

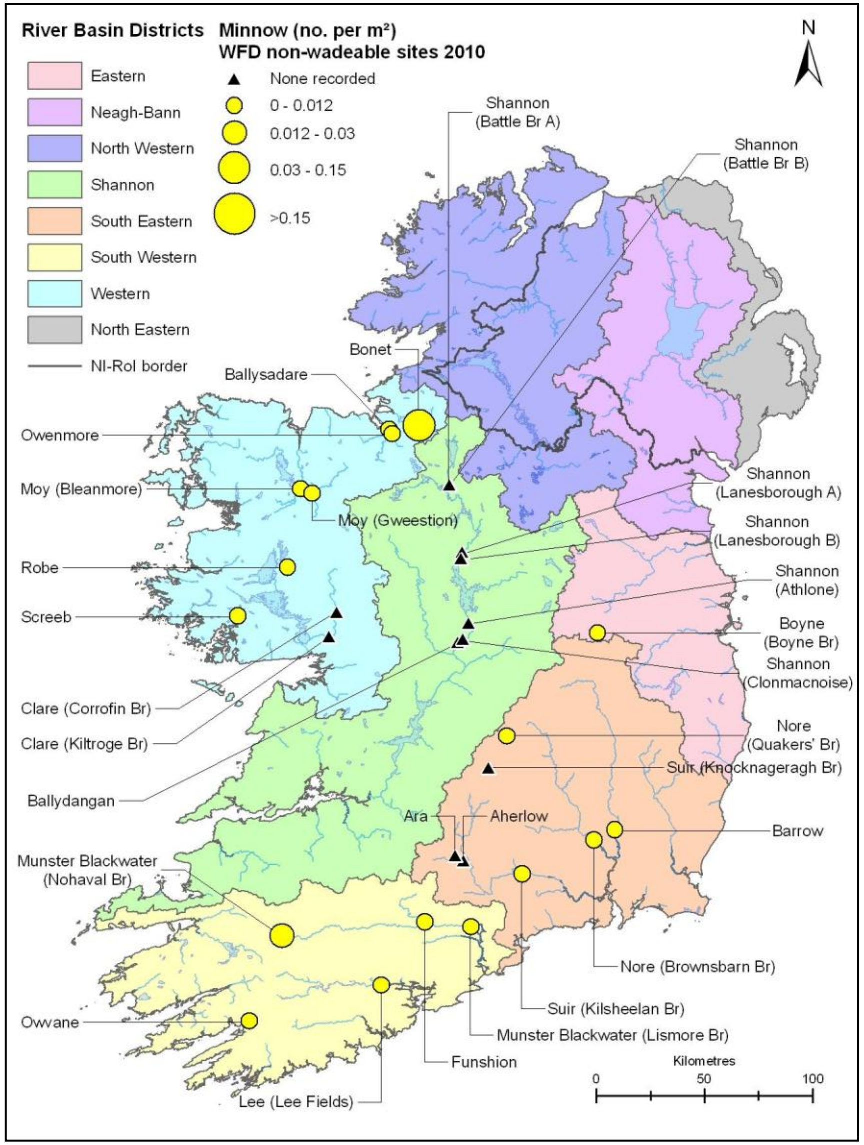

Fig. 4.69. Distribution and abundance of minnow at non-wadeable river sites surveyed for WFD fish monitoring 2010

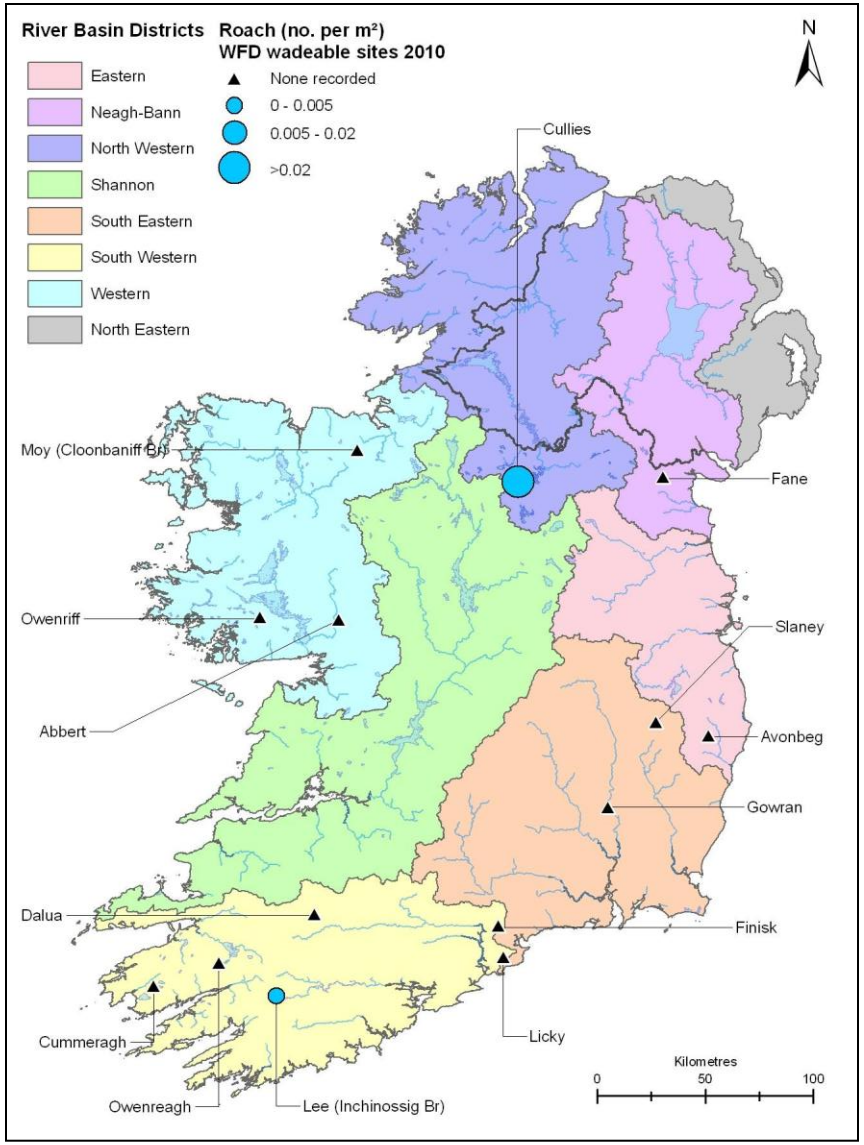

Fig. 4.70. Distribution and abundance of roach at wadeable river sites surveyed for WFD fish monitoring 2010

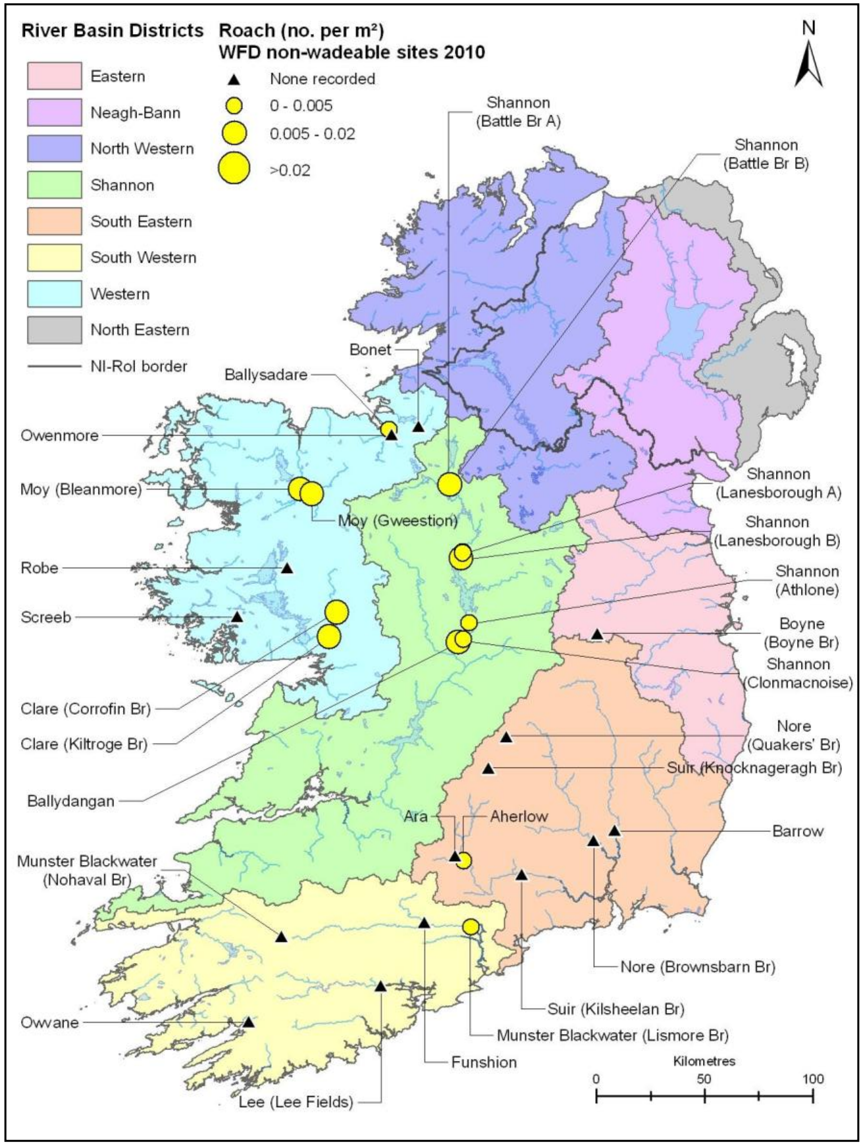

Fig. 4.71. Distribution and abundance of roach at non-wadeable river sites surveyed for WFD fish monitoring 2010

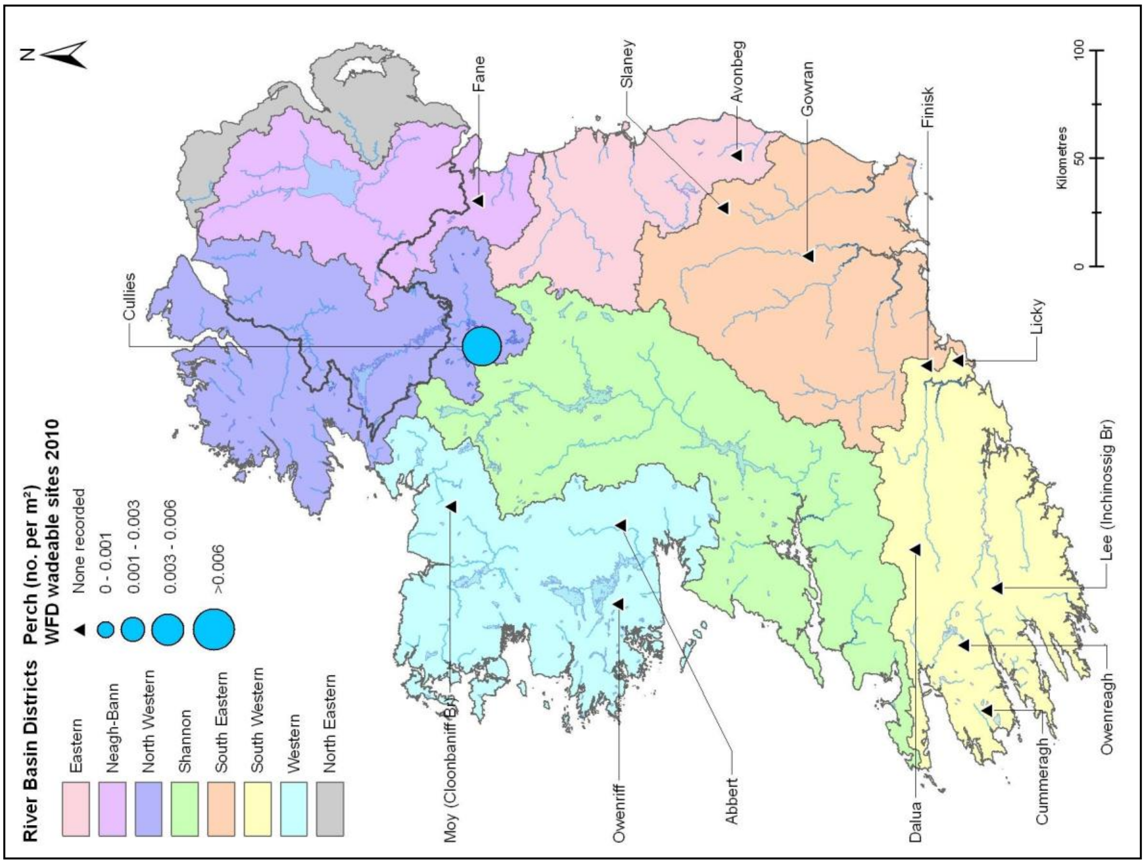

Fig. 4.72. Distribution and abundance of perch at wadeable river sites surveyed for WFD fish monitoring 2010

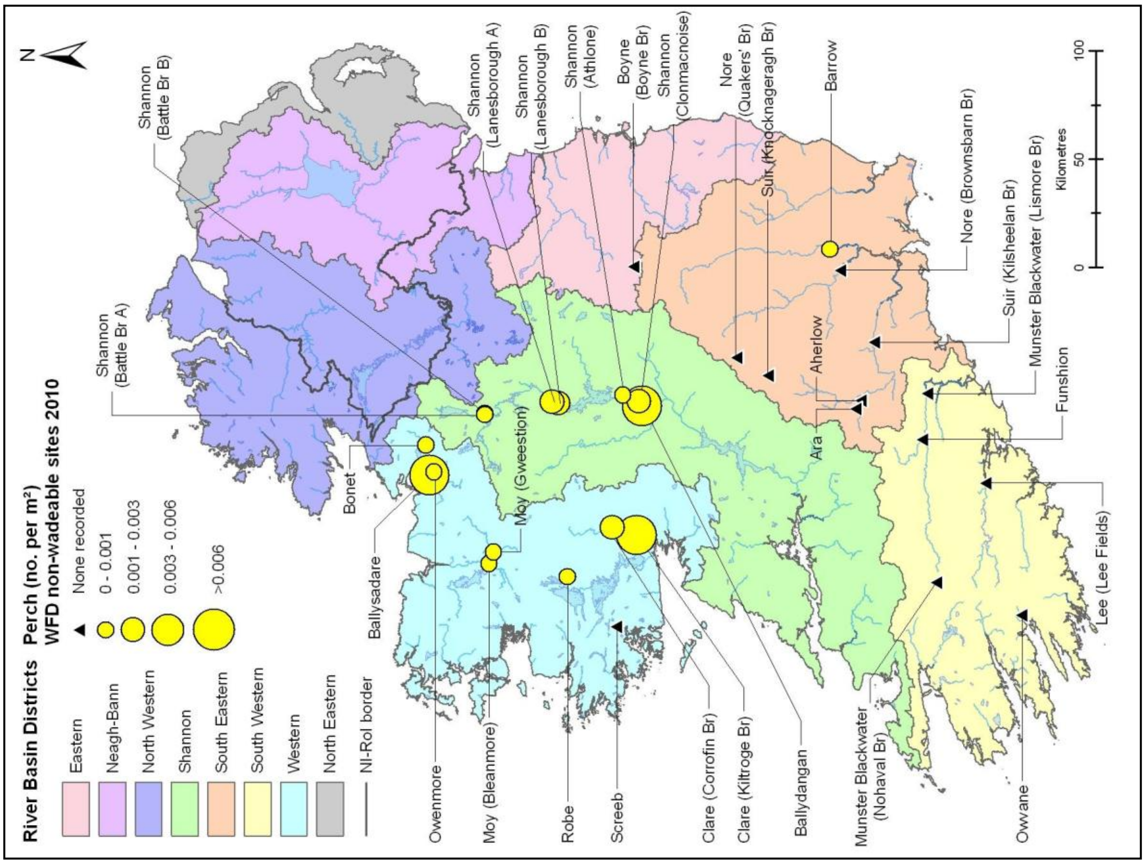

Fig. 4.73. Distribution and abundance of perch at non-wadeable river sites surveyed for WFD fish monitoring 2010

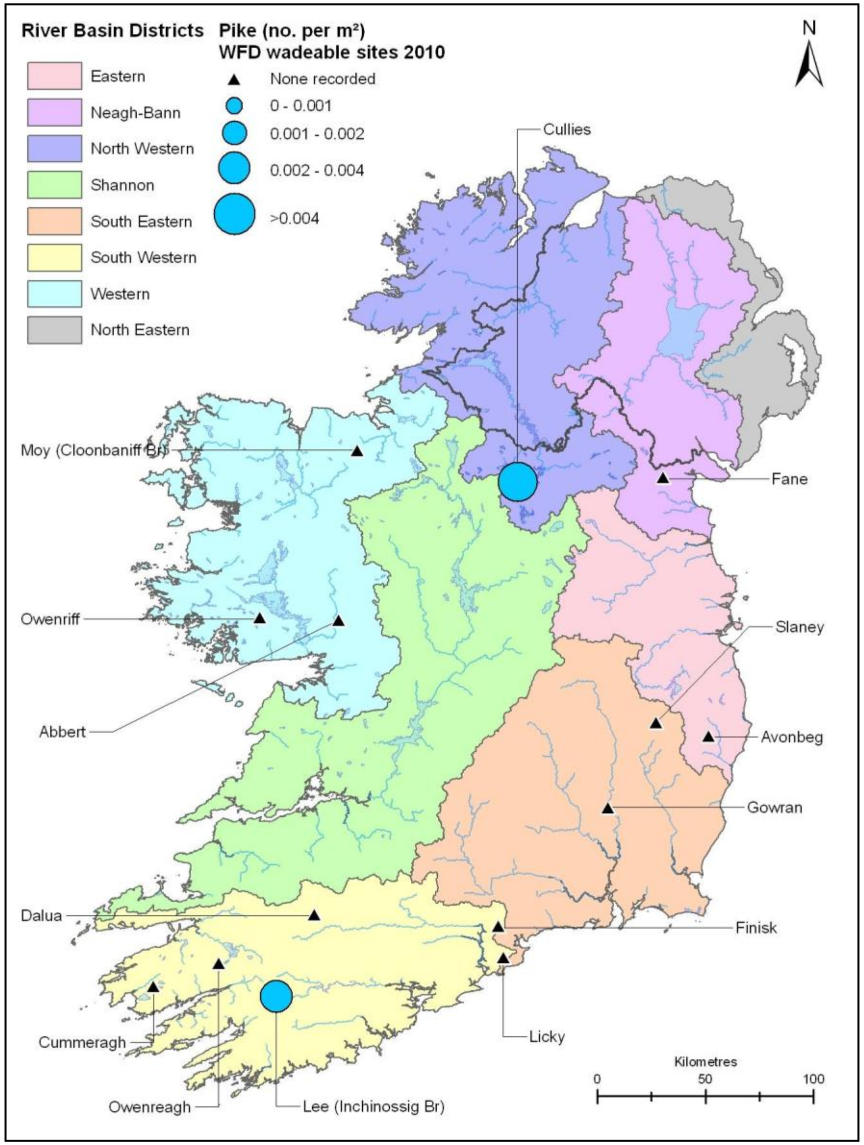

Fig. 4.74. Distribution and abundance of pike at wadeable river sites surveyed for WFD fish monitoring 2010

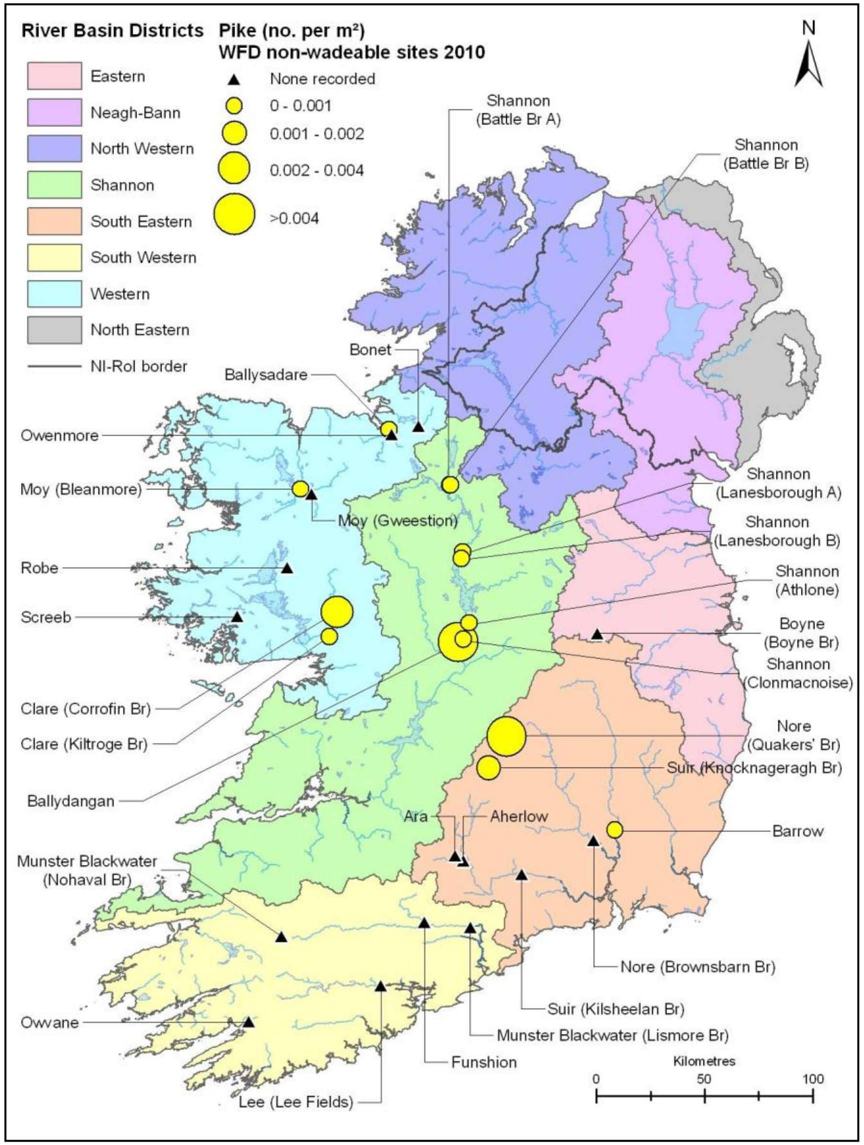

Fig. 4.75. Distribution and abundance of pike at non-wadeable river sites surveyed for WFD fish monitoring 2010

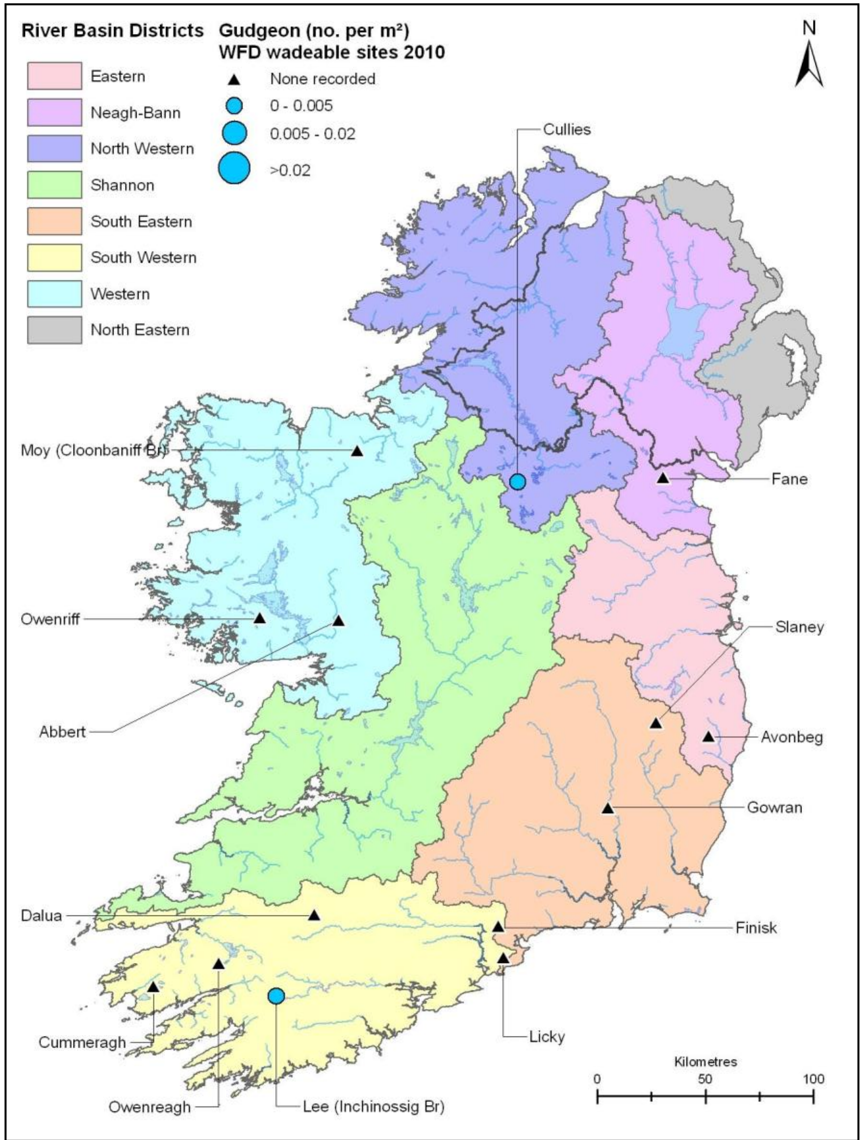

Fig. 4.76. Distribution and abundance of gudgeon at wadeable river sites surveyed for WFD fish monitoring 2010

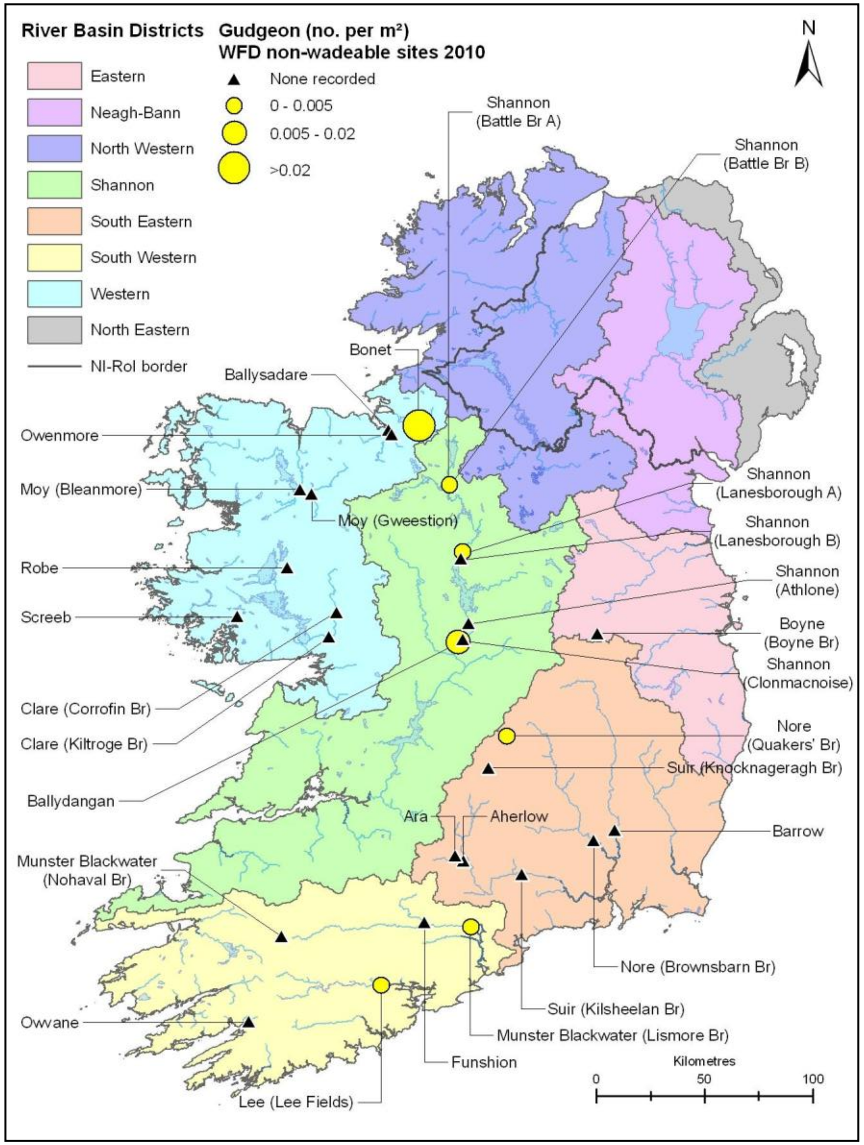

Fig. 4.77. Distribution and abundance of gudgeon at non-wadeable river sites surveyed for WFD fish monitoring 2010

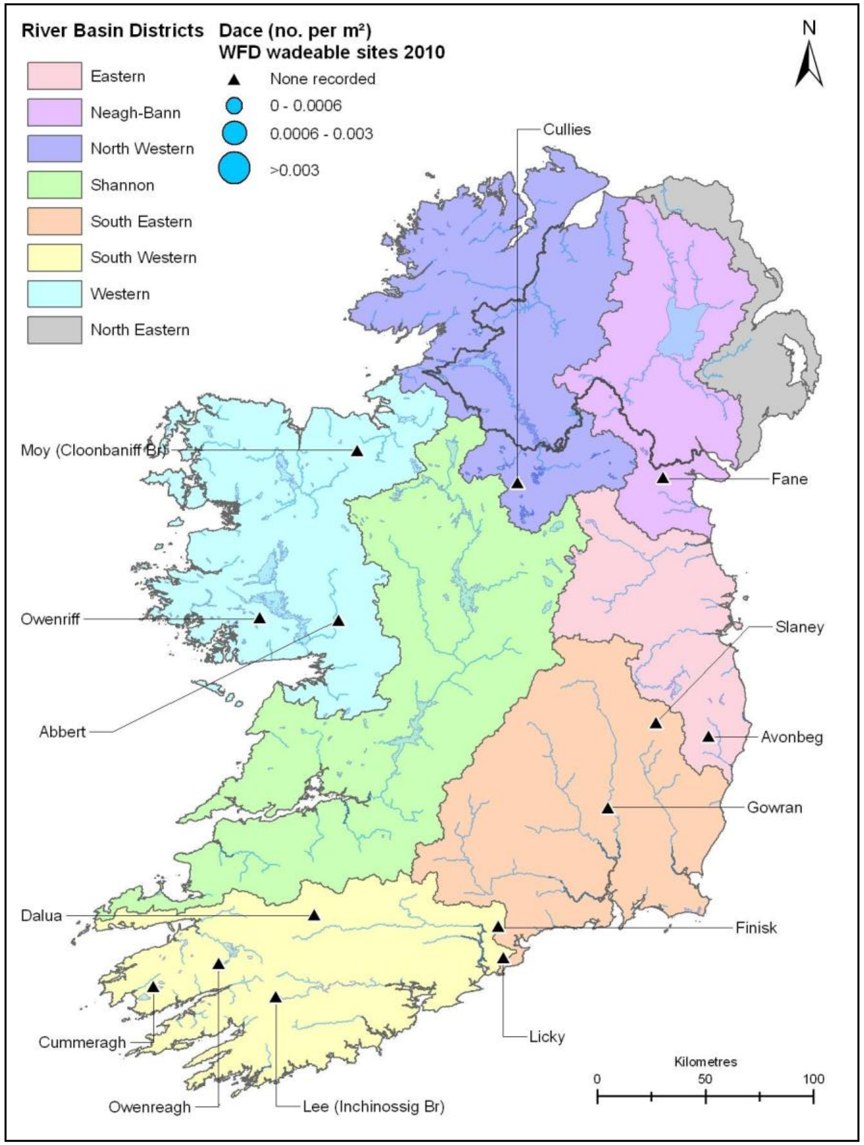

Fig. 4.78. Distribution and abundance of dace at wadeable river sites surveyed for WFD fish monitoring 2010

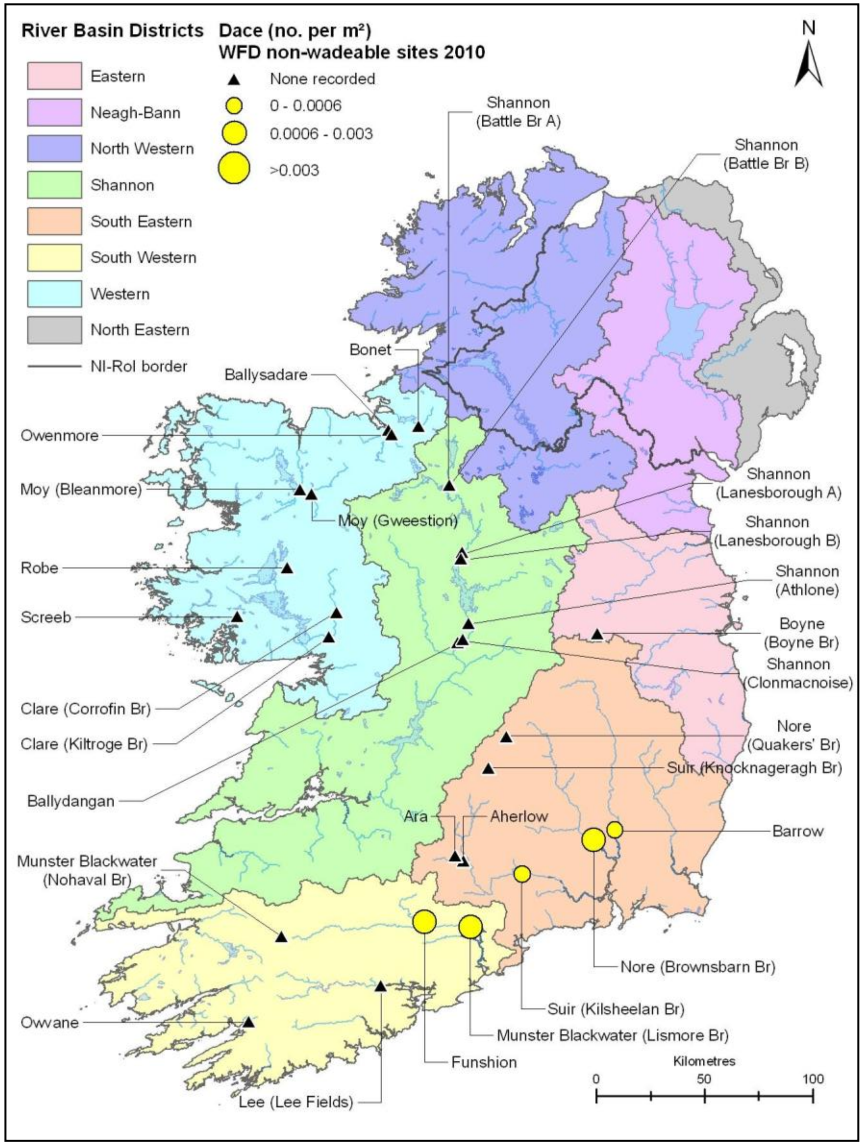

Fig. 4.79. Distribution and abundance of dace at non-wadeable river sites surveyed for WFD fish monitoring 2010

4.2.3 Fish growth

Scales from a total of 820 brown trout (34 river sites), 652 salmon (29 river sites), six sea trout (3 river sites), 485 roach (16 river sites), 121 pike (16 river sites), 3 bream (3 river sites), 9 roach x bream hybrids (2 river sites), 39 dace (5 river sites) and 4rudd (2 river sites) were examined for age and growth analysis. Where large numbers of any species was captured at a site, scales were analysed from five fish within each 1cm size class.

Brown trout ages ranged from 0+ to 4+. The most common ages were between 0+ and 3+, with older fish (4+) being relatively rare. As expected, larger brown trout were usually recorded in the wider and deeper sites, whilst the younger age classes were more numerous in the shallower sites. The largest brown trout recorded during the survey was captured in the Clare River at Corrofin Bridge (Galway), measuring 50.0cm in length. Appendix 7 provides a summary of the mean back-calculated lengths at age of brown trout in 35 river sites.

Salmon fry (0+) and parr (1+ and 2+) were the most common age groups recorded during the surveys. The largest salmon recorded (aged 4+), measuring 43.7cm in length and 909g in weight, was captured in the Munster Blackwater River at Lismore. Appendix 8 provides a summary of the mean back-calculated lengths at age of salmon in 29 rivers.

Roach ranged in age from 0+ to 9+. The largest roach recorded (River Shannon, Ballyleague Br. Site B) measured 27.5cm in length and 426g in weight. The largest perch was captured on the River Shannon at Clonmacnoise, measuring 29.6cm in length and 375g in weight. The largest and oldest pike recorded (10+) was captured in the River Shannon at Ballyleague Bridge (Site B), measuring 101cm in length and weighing 11kg.

4.2.3.1 Growth of brown trout

For each river where sufficient brown trout numbers were captured (n=32), the back-calculated mean lengths of brown trout at L2, L3 and L4 were compared to the back-calculated mean lengths described by Kennedy and Fitzmaurice (1971), as shown in Table 4.7. The alkalinity ranges observed for the four growth categories during 2010 are shown in parentheses and differ quite noticeably from the observations of Kennedy and Fitzmaurice for each growth category. A summary of the back calculated lengths for brown trout surveyed during 2010 is shown in Appendix 7.

Table 4.7.Categories of growth of Irish stream and river brown trout (Kennedy and Fitzmaurice, 1971)

Growth category	Mean length (cm)			Alkalinity (mg $CaCO_3$ l^{-1})
	L2	L3	L4	(Range observed in the current report)
Very slow	12	15–16	17–18	10.0 – 20.0 (4.3 – 212.0)
Slow	13–14	18–19	20–21	25.0 – 100.1 (2.1 – 319.9)
Fast	18–20	24–25	29–30	25.0 – 140.1 (77.3 – 367.7)
Very fast	20	30	35–40	>150.1 (279.0)

Brown trout from three river sites were classed as very slow, 19 were classed as slow, nine were classed as fast and one was classed as very fast (Table 4.8).

Table 4.8.Categories of growth of brown trout in the WFD river sites 2010 using Kennedy and Fitzmaurice (1971)

Very slow	Slow	Fast	Very fast
Abbert	Aherlow	Ballydangan	Clare (Kiltroge)
Avonbeg	Ara	Ballysadare	
Owvane (Cork)	Blackwater (Nohaval)	Fane	
	Bonet	Finisk	
	Boyne	Gowran	
	Cullies	Owenmore (Sligo)	
	Dalua	Robe	
	Funshion	Suir (Kilsheelan)	
	Lee (Inchinossig)	Suir (Knocknageragh)	
	Lee (Lee Fields)		
	Licky		
	Moy (Bleanmore)		
	Moy (Cloonbaniff)		
	Moy (Gweestion)		
	Nore (Brownsbarn)		
	Nore (Quakers')		
	Owenreagh		
	Owenriff		
	Slaney		

Rivers containing 1+ and older brown trout were also divided into three categories based on their alkalinity; low (<35 mg$CaCO_3$ l^{-1}), moderate (35 – 100 mg$CaCO_3$ l^{-1}) and high (>100 mg$CaCO_3$ l^{-1}). Seven were characterised as low alkalinity, seven as moderate alkalinity and 20 as high alkalinity. Statistical analyses (Kruskal-Wallis) were conducted to assess the differences in mean length at age of brown trout among the three alkalinity groups for L1 to L3 (Fig. 4.80).

There was a significant difference in L1 across the three alkalinity groups (H_2=7.805, P=0.020, with the mean L1 in low alkalinity lakes being significantly lower than the high alkalinity lakes (Mann-Whitney U=24, z=-2.548, p=0.011). However there were no significant differences between the low and moderate or moderate and high alkalinity groups. There was no significant difference in L2 across the different alkalinity groups, however a significant difference (U=31, z=-2.056, p=0.040) was observed for L2 between the low and high alkalinity categories alone. No significant differences were observed for L3 across the different alkalinity groups.

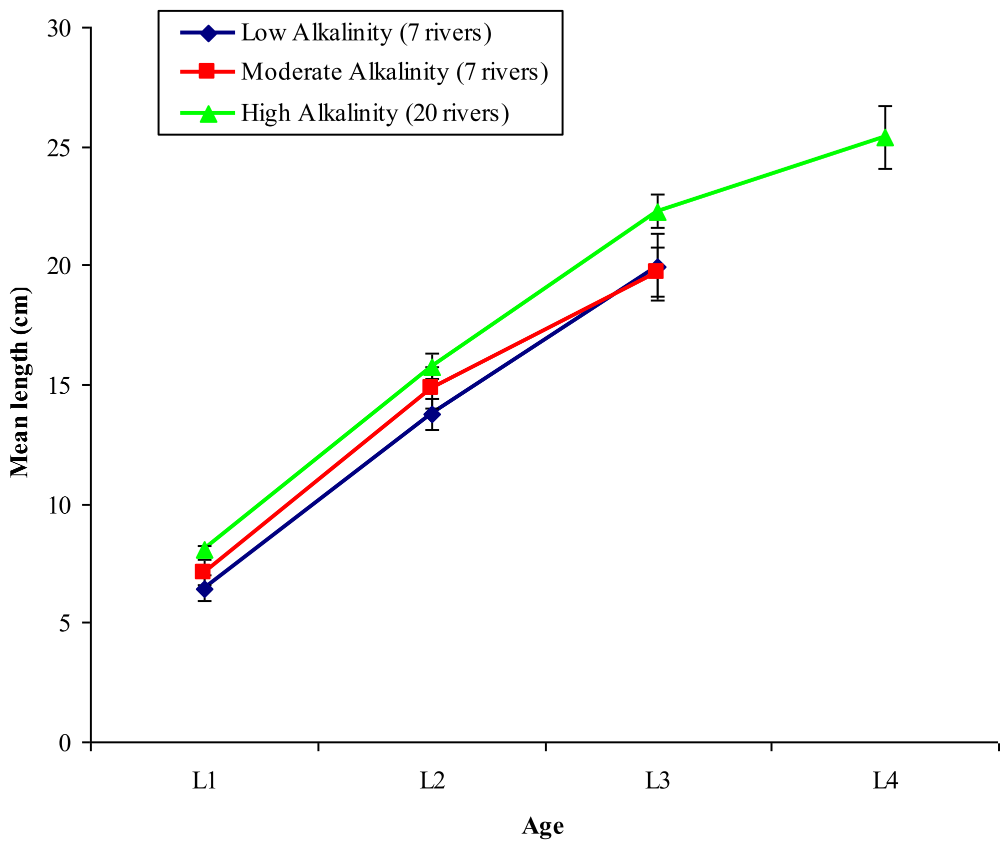

Fig. 4.80. Mean (±S.E.) back calculated lengths at age for brown trout in rivers within each alkalinity class

4.2.3 Ecological status – Classification of rivers using 'FCS2 Ireland'

An ecological classification tool for fish in rivers has recently been developed for Ecoregion 17 (Republic of Ireland and Northern Ireland), along with a separate version for Scotland to comply with the requirements of the WFD. Agencies throughout each of the three regions have contributed data which was used in the model development. It was recommended during the earlier stages of this project that an approach similar to that developed by the Environment Agency in England and Wales

(Fisheries Classification Scheme 2, or 'FCS2') be used. This approach has broadly been followed and improved to develop the new classification tool – 'FCS2 Ireland'. The tool works by comparing various fish community metric values within a site (observed) to those predicted (expected) for that site under reference (un-impacted) conditions using a geo-statistical model based on Bayesian probabilities. The resultant output is an Ecological Quality Ratio (EQR) between 1 and 0, with five class boundaries defined along this range corresponding with the five ecological status classes of High, Good, Moderate, Poor and Bad. Confidence levels are assigned to each class and represented as probabilities. The tool is currently undergoing the EU intercalibration process to standardise results across Europe. FCS2 Ireland has been used, along with expert opinion, to classify 39 of the 43 river sites surveyed during 2010; 4 (10%) river sites were classified as High, 17 (44%) as Good, 18 (46%) as Moderate, zero as Poor and zero as Bad ecological status (Table 4.9, Fig. 4.81). Four sites were not classified due to river conditions during the time of the survey being inappropriate for collection of reliable data.

Table 4.9. Classification of river sites using the FCS2 Ireland classification tool

River	Site name	Catchment	Site code	Ecological status
ERBD Hand-set sites				
Avonbeg	Greenan Br	Avoca	IE10A040600F	Good
ERBD Boat sites				
Boyne	Boyne Br	Boyne	IE07B040200	Moderate
NBIRBD Hand-set sites				
Fane	Br d/s of Inniskeen	Fane	IE06F010650	Good
NWIRBD Hand-set sites				
Cullies	Br nr Kilbrackan Ho	Erne	IE36C030600	Moderate
SERBD Hand-set sites				
Gowran	Br N of Goresbridge (S Channel)	Barrow	IE14G030300	Moderate
Slaney	Waterloo Br.	Slaney	IE12S020400	High
SERBD Boat sites				
Aherlow	Killardy Br	Suir	IE16A010900	Good
Ara	Ara Br	Suir	IE16A030600	High
Barrow	Graiguenamanagh Br.	Barrow	IE14B013500	N/A
Nore	Brownsbarn Br.	Nore	IE15N012400	Good
Nore	Quakers' Br.	Nore	IE15N010300	Moderate
Suir	Kilsheelan Br.	Suir	IE16S022700	Good
Suir	Knocknageragh Br.	Suir	IE16S020200	Good
ShIRBD Boat sites				
Shannon (Upper)	Battle Br. (a)	Shannon Upper	IE26S020500a	Moderate
Shannon (Upper)	Battle Br. (b)	Shannon Upper	IE26S020500b	Moderate
Shannon (Upper)	Ballyleague Br. (a)	Shannon Upper	IE26S021600a	Moderate
Shannon (Upper)	Ballyleague Br. (b)	Shannon Upper	IE26S021600b	Moderate
Shannon (Upper)	Athlone d/s of Burgess Park	Shannon Upper	IE26S021720	Moderate
Shannon (Upper)	Clonmacnoise: at Jetty	Shannon Upper	IE26S021800	Moderate
Ballydangan	Br u/s Shannon R. confluence	Shannon Upper	IE26B140200	Moderate
SWRBD Hand-set sites				
Cummeragh	U/s Owengarriff confluence	Cummeragh	IE21C040400F	High
Dalua	Ford and foobridge	Blackwater	IE18D010200	Good
Finisk	Modelligo Br	Blackwater	IE18F020300	Good
Lee (Cork)	Inchinossig Br.	Lee	IE19L030100	N/A
Licky	Br. NE of Glenlicky	Blackwater	IE18L010100	Moderate
Owenreagh	Br. u/s Upper Lake	Laune	IE22O030400	Good
SWRBD Boat sites				
Blackwater Munster)	Lismore Br.	Blackwater	IE18B022600	Moderate
Blackwater Munster)	Nohaval Br.	Blackwater	IE18B020200	High
Funshion	Br u/s Blackwater R confluence	Blackwater	IE18F051100	Good
Lee (Cork)	Lee fields	Lee	IE19L030700	Moderate
Owvane (Cork)	Lisheen / Piersons Br.	Owvane	IE21O070400	N/A

Table 4.9 ctn. Classification of river sites using the FCS2 Ireland classification tool

River	Site name	Catchment	Site code	Ecological status
WRBD Hand-set sites				
Abbert	Bridge at Bullaun	Corrib	IE30A010500	Good
Moy	Cloonbaniff Br.	Moy	IE34M020050	Moderate
Owenriff	D/s of Lough Agraffard	Corrib	IE30O020070F	Good
WRBD Boat sites				
Ballysadare	Ballysadare Br.	Ballysadare	IE35B050100	Good
Bonet	1.8 km d/s Dromahaire Bridge	Garvogue	IE35B060600	Moderate
Clare	Corrofin Br	Corrib	IE30C010800	Moderate
Clare	Kiltroge Castle br.	Corrib	IE30C011150F	Good
Moy	At Bleanmore	Moy	IE34M020750	Good
Moy	Ford 2 km u/s Gweestion River	Moy	IE34M020650	Good
Owenmore (Sligo)	300 m u/s Unshin River confluence	Ballysadare	IE35O060900	Good
Robe	Akit Br.	Corrib	IE30R010600	Moderate
Screeb	d/s of Loughaunfree	Screeb	IE31S010300	N/A

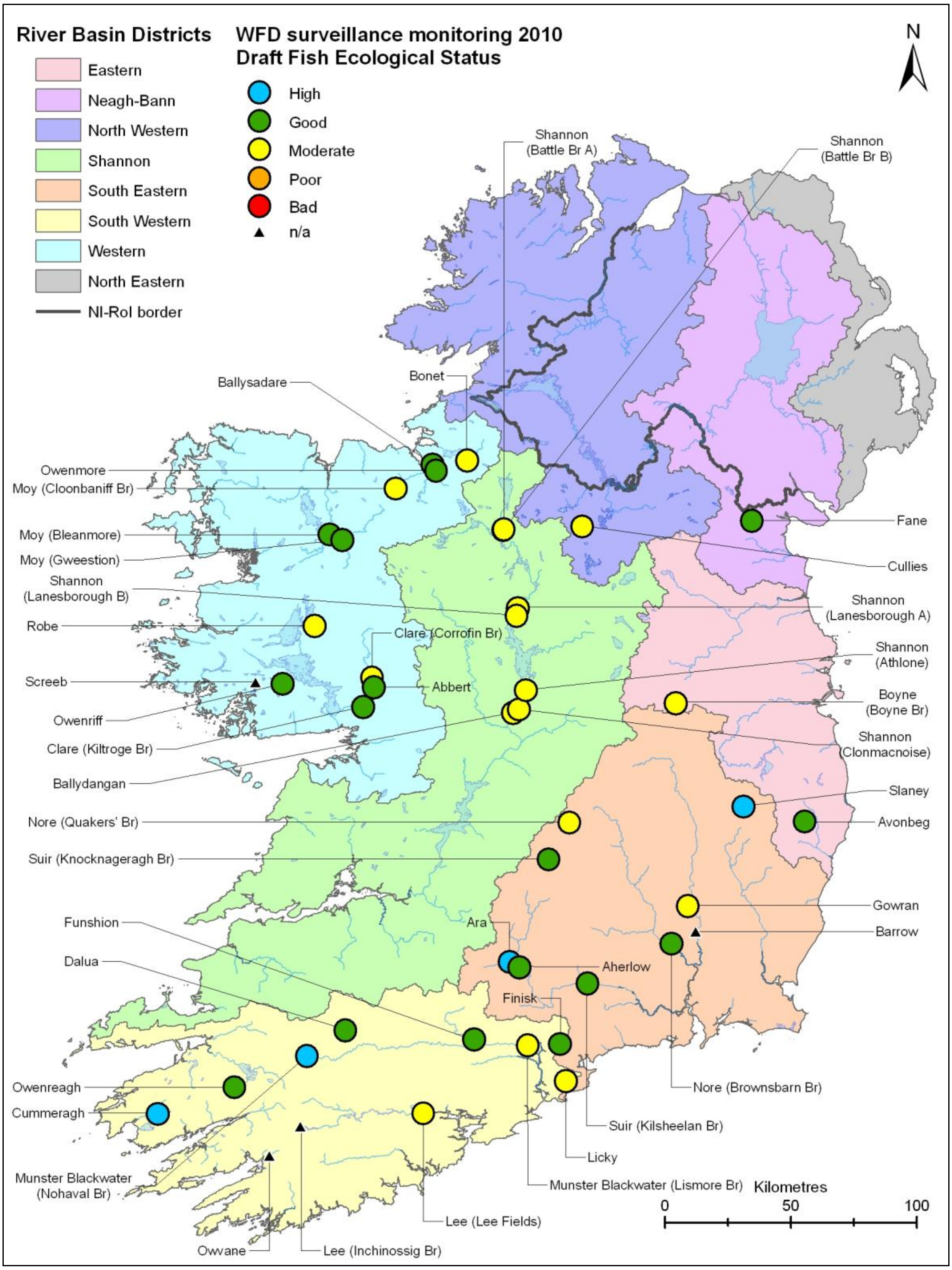

Fig. 4.81.Classification of river sites using the FCS2 Ireland classification tool

4.3 Transitional waters

4.3.1 Fish species composition and richness

WFD requires that information be collected on the composition and abundance of fish species in transitional waters. Estuaries have been exploited by fish over a long evolutionary period, with many fish species availing of the highly productive nature of estuaries for all or part of their life cycle. Fish species in transitional waters can be grouped into a number of different guilds depending on their life history (euryhaline, diadromous, estuarine, marine and freshwater). Some fish species are migratory, travelling through estuaries from the sea to reach spawning grounds in freshwater (e.g. salmon and lamprey), or migrating downstream through estuaries as adults to spawn at sea (e.g. eels).

A total of 55 fish species (sea trout are included as a separate "variety" of trout) were recorded in the 25 transitional water bodies surveyed during 2010 (Table 4.10). A list of fish species recorded in each individual water body can be found in the detailed transitional water reports on the dedicated WFD fish website for Ireland, www.wfdfish.ie.

The three most frequently encountered species recorded during the 2010 surveys were flounder (100% of sites), sand goby (96%) and eel (88%). Other commercially important species such as cod, thick-lipped grey mullet and plaice were recorded in 56%, 72% and 48% of transitional water bodies respectively.

Species richness ranged from three species in the Glashaboy Estuary to 23 species in the North Channel Great Island transitional water body (Table 4.11, Fig. 4.82). Three estuaries contained 20 or more fish species (North Channel Great Island; Barrow-Suir-Nore Estuary and Inner Kenmare River), while ten estuaries contained ten fish species or less.

Table 4.10. Species present in transitional water bodies surveyed during 2010

	Scientific name	Common name	Number of transitional water bodies	% transitional water bodies
1	*Platichthys flesus*	Flounder	25	100
2	*Pomatoschistus minutus*	Sand goby	24	96
3	*Anguilla anguilla*	European eel	22	88
4	*Chelon labrosus*	Thick-lipped grey mullet	18	72
5	*Gadus morhua*	Cod	14	56
6	*Atherina presbyter*	Sand smelt	13	52
7	*Gasterosteus aculeatus*	Three-spined stickleback	13	52
8	*Sprattus sprattus*	Sprat	13	52
9	*Ciliata mustela*	Five-bearded rockling	12	48
10	*Pleuronectes platessa*	Plaice	12	48
11	*Salmo trutta*	Brown trout	10	40
12	*Pollachius pollachius*	Pollack	8	32
13	*Spinachia spinachia*	Fifteen-spined stickleback	8	32
14	*Syngnathus acus*	Greater pipefish	8	32
15	*Osmerus eperlanus*	Smelt *	7	28
16	*Salmo trutta*	Sea trout **	7	28
17	*Taurulus bubalis*	Long-spined sea scorpion	7	28
18	*Alosa fallax*	Twaite shad *	6	24
19	*Leuciscus leuciscus*	Dace	6	24
20	*Merlangius merlangus*	Whiting	6	24
21	*Salmo salar*	Salmon *	6	24
22	*Trachurus trachurus*	Scad	6	24
23	*Ammodytes tobianus*	Lesser sandeel	4	16
24	*Crenilabrus melops*	Corkwing wrasse	4	16
25	*Pomatoschistus microps*	Common goby	4	16
26	*Agonus cataphractus*	Pogge	3	12
27	*Dicentrarchus labrax*	European seabass	3	12
28	*Gobiusculus flavescens*	Two-spot goby	3	12
29	*Lampetra fluviatilis*	River lamprey	3	12
30	*Limanda limanda*	Dab	3	12
31	*Melanogrammus aeglefinus*	Haddock	3	12
32	*Myoxocephalus scorpius*	Short-spined sea scorpion	3	12
33	*Pholis gunnellus*	Gunnel (Butterfish)	3	12
34	*Rutilus rutilus*	Roach	3	12
35	*Scophthalmus rhombus*	Brill	3	12
37	*Syngnathus rostellatus*	Nilsson's pipefish	3	12
36	*Labrus bergylta*	Ballan wrasse	2	8
38	*Perca fluviatilis*	Perch	2	8
39	*Phoxinus phoxinus*	Minnow	2	8
40	*Pomatoschistus pictus*	Painted goby	2	8
41	*Scyliorhinus canicula*	Lesser spotted dogfish	2	8
42	*Syngnathus typhle*	Deep-snouted pipefish	2	8
43	*Aspitrigla cuculus*	Red gurnard	1	4
44	*Callionymus lyra*	Common dragonet	1	4
45	*Callionymus maculatus*	Spotted dragonet	1	4
46	*Ctenolabrus rupestris*	Goldsinny wrasse	1	4
47	*Echiichthys vipera*	Lesser Weever	1	4
48	*Gaidropsarus vulgaris*	Three-bearded rockling	1	4
49	*Gobius niger*	Black goby	1	4
50	*Liza aurata*	Golden grey mullet	1	4
51	*Pungitius pungitius*	Nine-spined stickleback	1	4
52	*Scardinius erythrophthalmus*	Rudd	1	4
53	*Solea solea*	Sole	1	4
54	*Trisopterus luscus*	Bib	1	4
55	*Trisopterus minutus*	Poor cod	1	4

Note: * indicates Red Data Book species, **sea trout are included as a separate “variety” of trout

Table 4.11. Species richness and most abundant species present in transitional water bodies surveyed during 2010

Water body	Type	Species richness	Most abundant species
North Channel Great Island	Transitional	23	Sand goby
Barrow-Suir-Nore Estuary	Transitional	22	Sprat
Kenmare River, Inner	Transitional	20	Scad
Rogerstown Estuary	Transitional	18	Sand goby
Liffey Estuary, Lower	Transitional	17	Thick-lipped grey mullet
Broad Lough	Transitional	16	Sand goby
Mahon, Lough	Transitional	16	Sprat
Suir Estuary, Lower	Transitional	15	Sand goby
New Ross Port	Transitional	15	Sprat
Tolka Estuary	Transitional	14	Sand goby
Suir Estuary, Middle	Transitional	13	Sand goby
Avoca Estuary	Transitional	12	Flounder
Broadmeadow Water	Lagoon	12	Sand goby
Barrow-Nore Estuary, Upper	Transitional	11	Sand goby
Owenacurra Estuary	Transitional	11	Sand goby
Suir Estuary, Upper	Freshwater Tidal	10	Flounder
Nore Estuary	Transitional	10	Flounder
Barrow Estuary, Upper	Transitional	10	Flounder
Mahon, Lough (Harper's Island)	Transitional	10	Sand goby
Liffey Estuary, Upper	Transitional	9	Sand goby
Lee (Cork) Estuary, Lower	Transitional	9	Sand goby
Lee (Cork) Estuary, Upper	Transitional	9	Common goby
Drongawn Lough	Lagoon	9	Three-spined stickleback
Gill, Lough	Lagoon	6	Three-spined stickleback
Glashaboy Estuary	Transitional	3	Sand goby

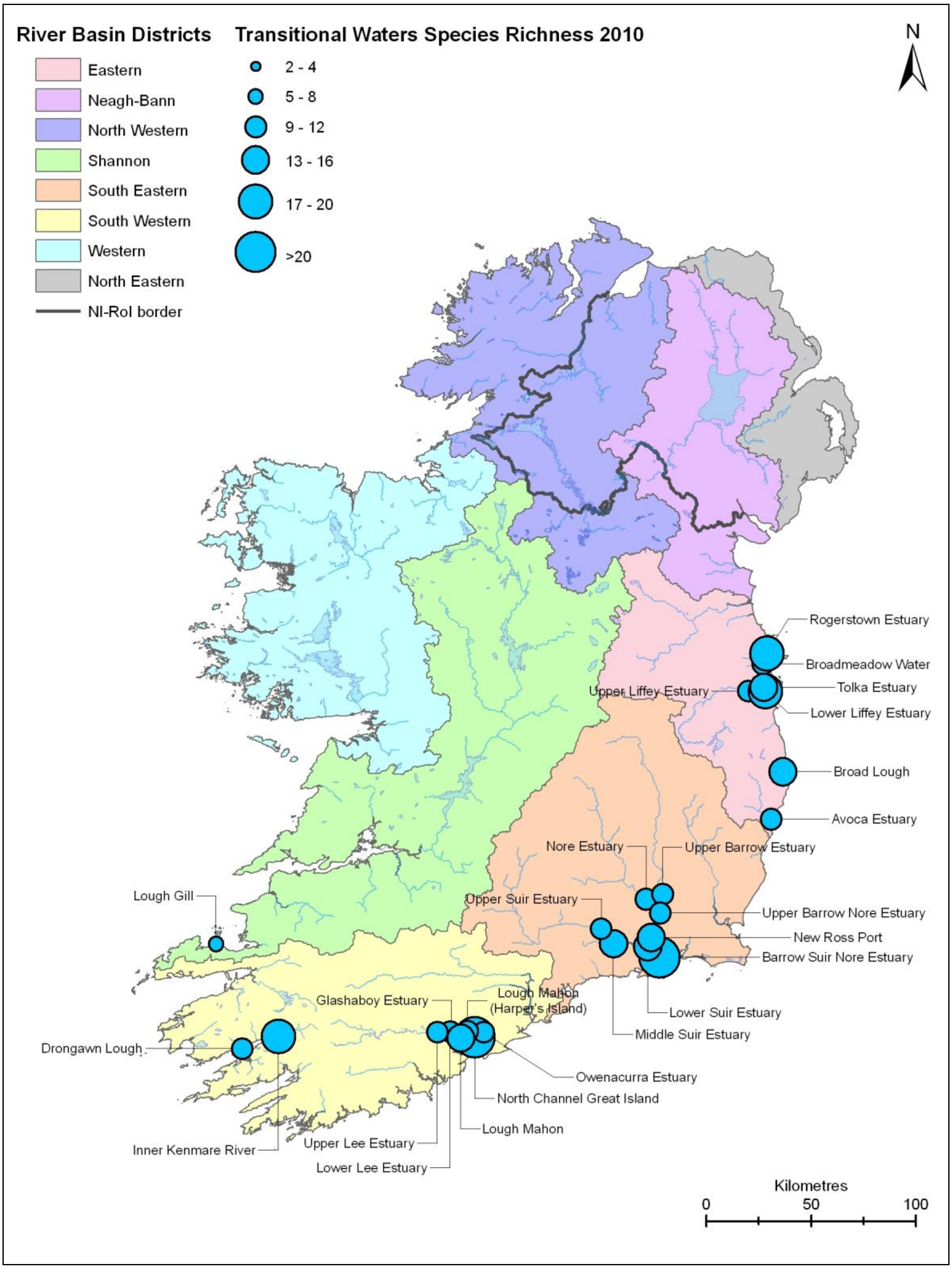

Fig. 4.82. Species richness in the 23 transitional water bodies surveyed during 2010

4.3.2 Fish species distribution

A large number of juvenile and immature fish were captured within the various sites surveyed, indicating the essential nursery function of these transitional water bodies. Figures 4.83 to 4.91 show the distribution of a selected number of the more abundant or commonly encountered fish species: eel, flounder, sand goby, salmon, brown trout, cod, pollack, sea trout and thick-lipped grey mullet.

A number of important angling species were recorded during surveys in 2010. Flounder were captured in 25 water bodies (Fig. 4.84), thick-lipped grey mullet in 18 water bodies (Plate 4.1, Fig. 4.91), cod in 14 water bodies (Plate 4.2, Fig. 4.88), pollack (Fig. 4.89) in eight water bodies and sea trout (Fig. 4.90) in seven water bodies. Sea bass were also recorded in three water bodies (Harper's Island in Greater Cork Harbour, the Lower Suir estuary and the Tolka estuary).

Plate 4.1. Thick-lipped grey mullet captured in the Lower Lee Estuary, October 2010

Plate 4.2. Cod captured in the Avoca Estuary, October 2010

In addition to the required fish metrics (fish species composition and abundance), WFD also requires Member States to report on the presence/absence of indicator species. Of particular importance are the diadromous or migratory fish species such as eel, salmon, sea trout, lampreys, smelt and shad. Twenty of the transitional water bodies surveyed during 2010 are incorporated in the series of Special Areas of Conservation (SACs), designated nationally. The legal basis on which SACs are selected and designated is the EU Habitats Directive, transposed into Irish law in the European Union (Natural Habitats) Regulations (SI No.94/1997) as amended in 1998 and 2005. The Directive lists certain habitats and species that must be protected within SACs. With regards to transitional water bodies, these habitats consist of coastal lagoons and estuaries. Protected "Red Data Book" (King *et al*., 2011) species that may occur in these habitats include river lamprey, sea lamprey, Atlantic salmon smelt, allis shad and twaite shad. Four red data book species were recorded during these surveys. Smelt was the most common species, recorded in seven sites, followed by twaite shad (6 sites, Plate. 4.3), salmon (6 sites) and river lamprey (3 sites).

Plate 4.3. Twaite shad captured in the Barrow-Suir-Nore estuary, September 2010

European eel is listed as a declining species and is included in Appendix II of the Convention on international trade in endangered species of wild flora and fauna (CITES). European Regulation (Regulation R (EC) 1100/2007) has set up measures for the recovery of the European eel stock. Eels were regularly captured using all three netting methods; however fyke nets proved most successful. During 2010, 22 out of the 25 transitional water bodies surveyed had eels present (Fig. 4.83). Data from the WFD surveys is also used to support the National Eel Management Plan.

Five freshwater species and invasive fish species were recorded during 2010: dace (Middle Suir Estuary, Upper Suir Estuary, Nore Estuary, Upper Barrow, Upper Barrow-Nore Estuary and New Ross Port), roach (Upper Liffey Estuary and Nore Estuary), perch (Upper Barrow–Nore Estuary and Upper Suir Estuary), minnow (Upper Barrow Estuary and Nore Estuary) and rudd (Middle Suir Estuary). These were encountered in less saline water bodies further upstream. More information is available in the individual water body reports available on www.wfdfish.ie.

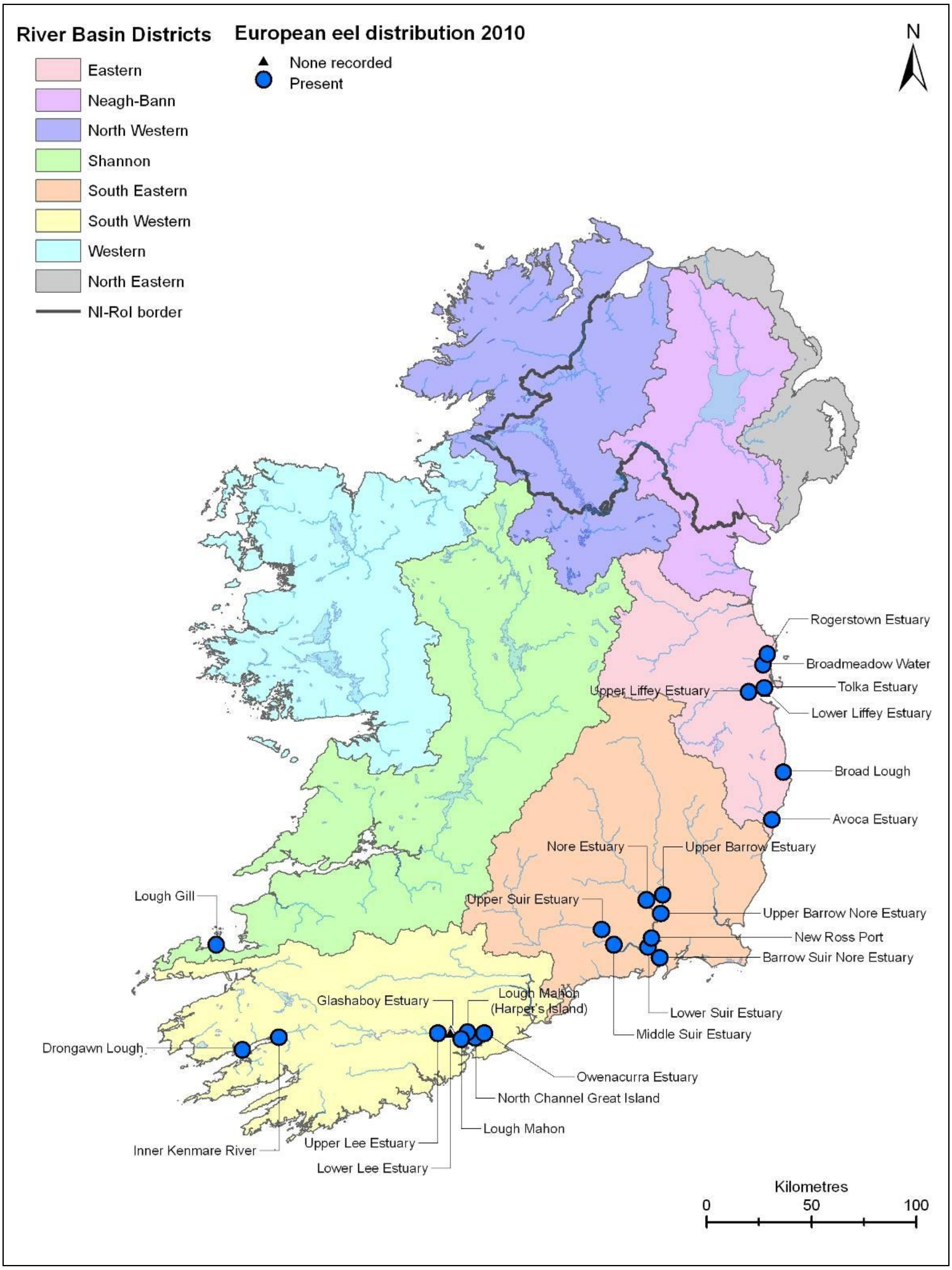

Fig. 4.83. European eel distribution in transitional waters surveyed for WFD fish monitoring 2010

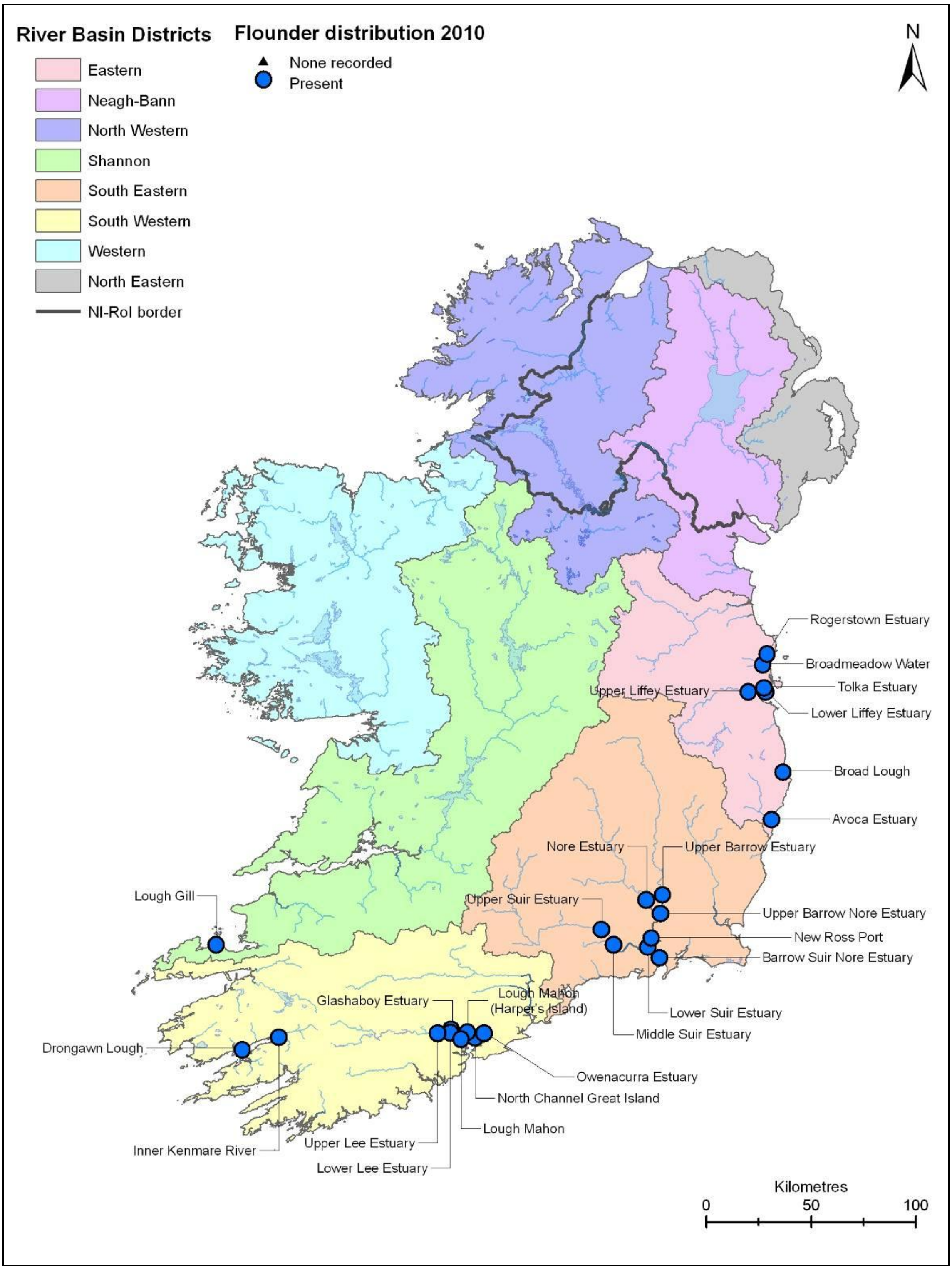

Fig. 4.84. Flounder distribution in transitional waters surveyed for WFD fish monitoring 2010

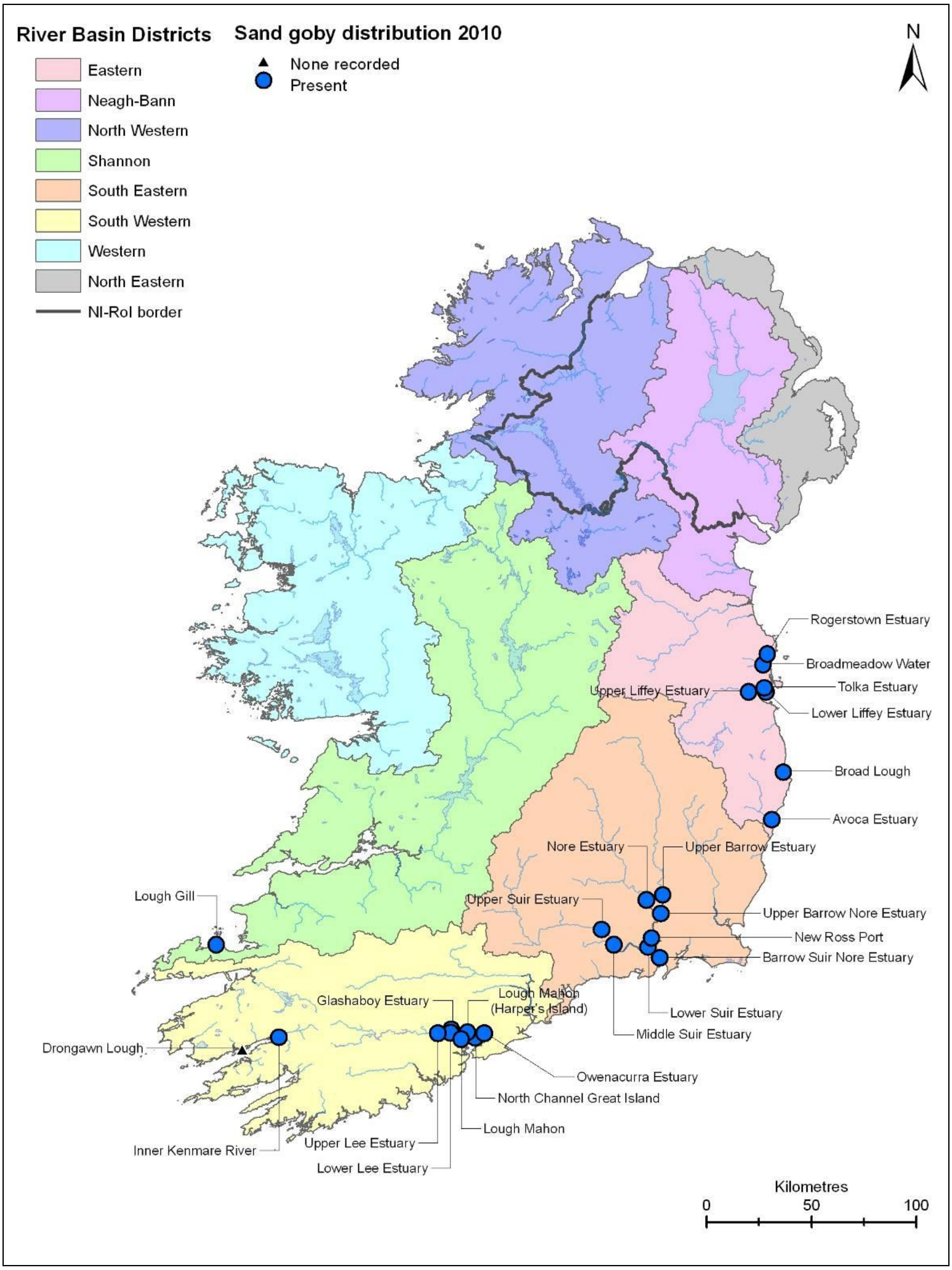

Fig. 4.85. Sand goby distribution in transitional waters surveyed for WFD fish monitoring 2010

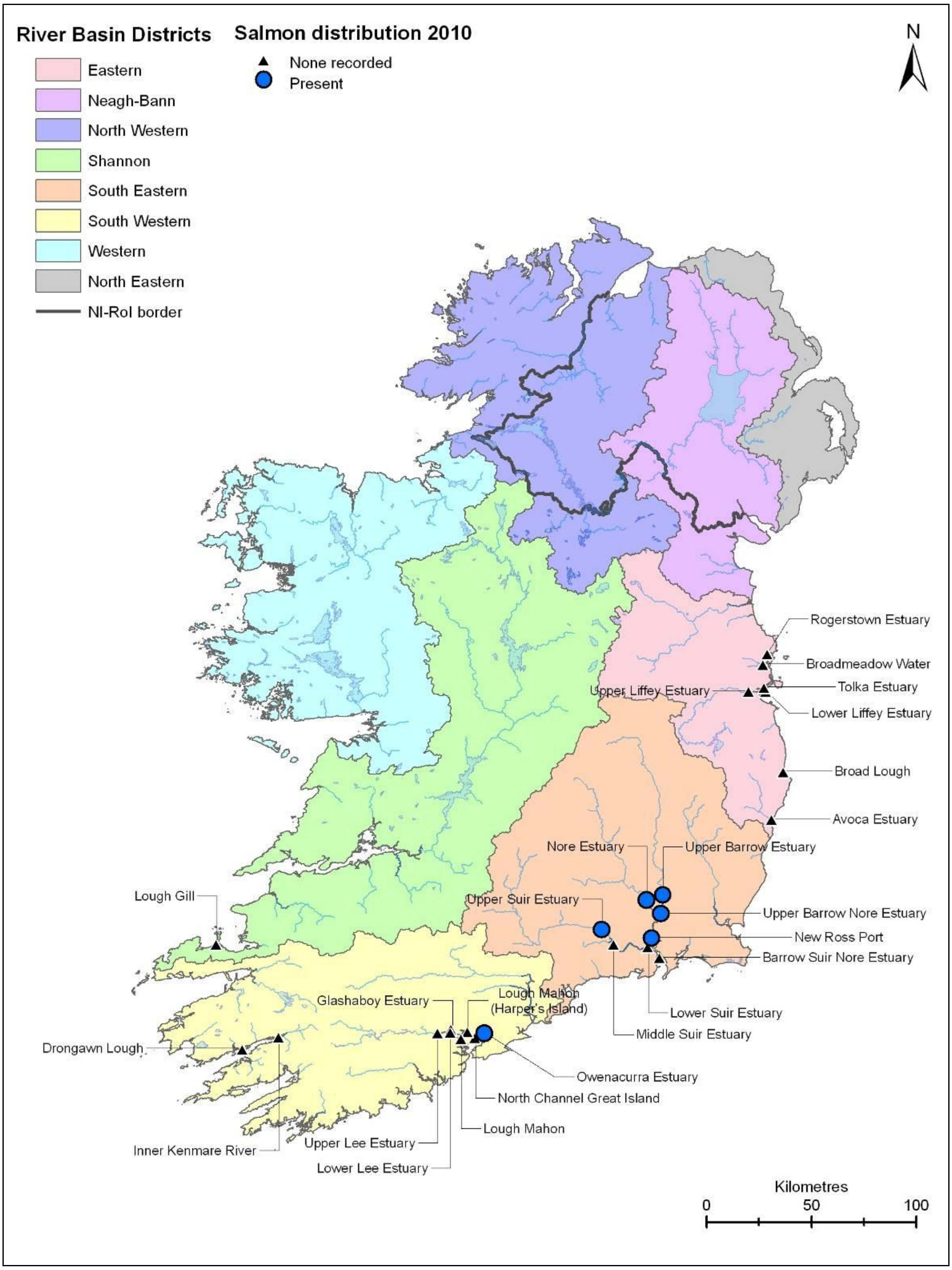

Fig. 4.86. Salmon distribution in transitional waters surveyed for WFD fish monitoring 2010

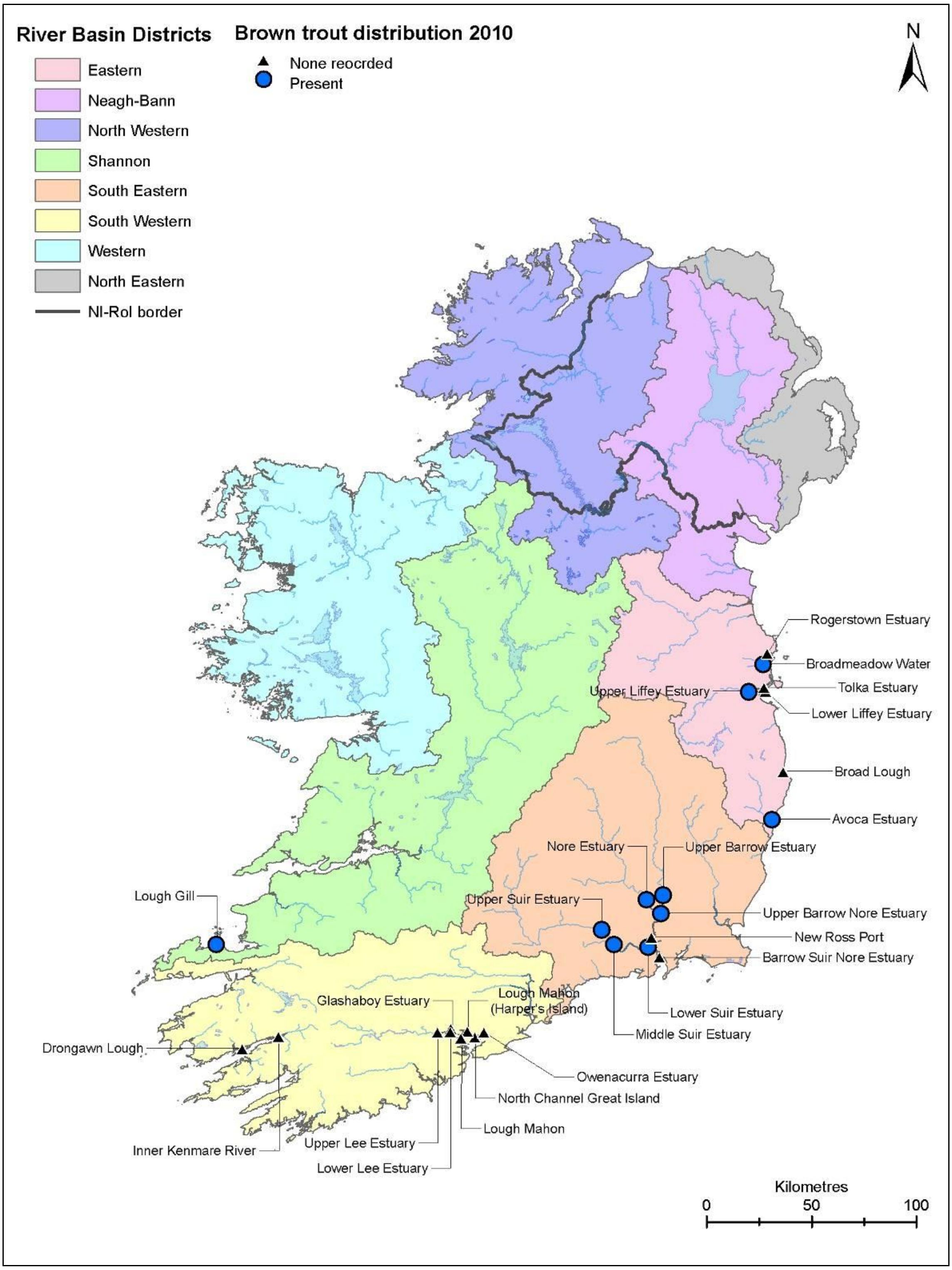

Fig. 4.87.Brown trout distribution in transitional waters surveyed for WFD fish monitoring 2010

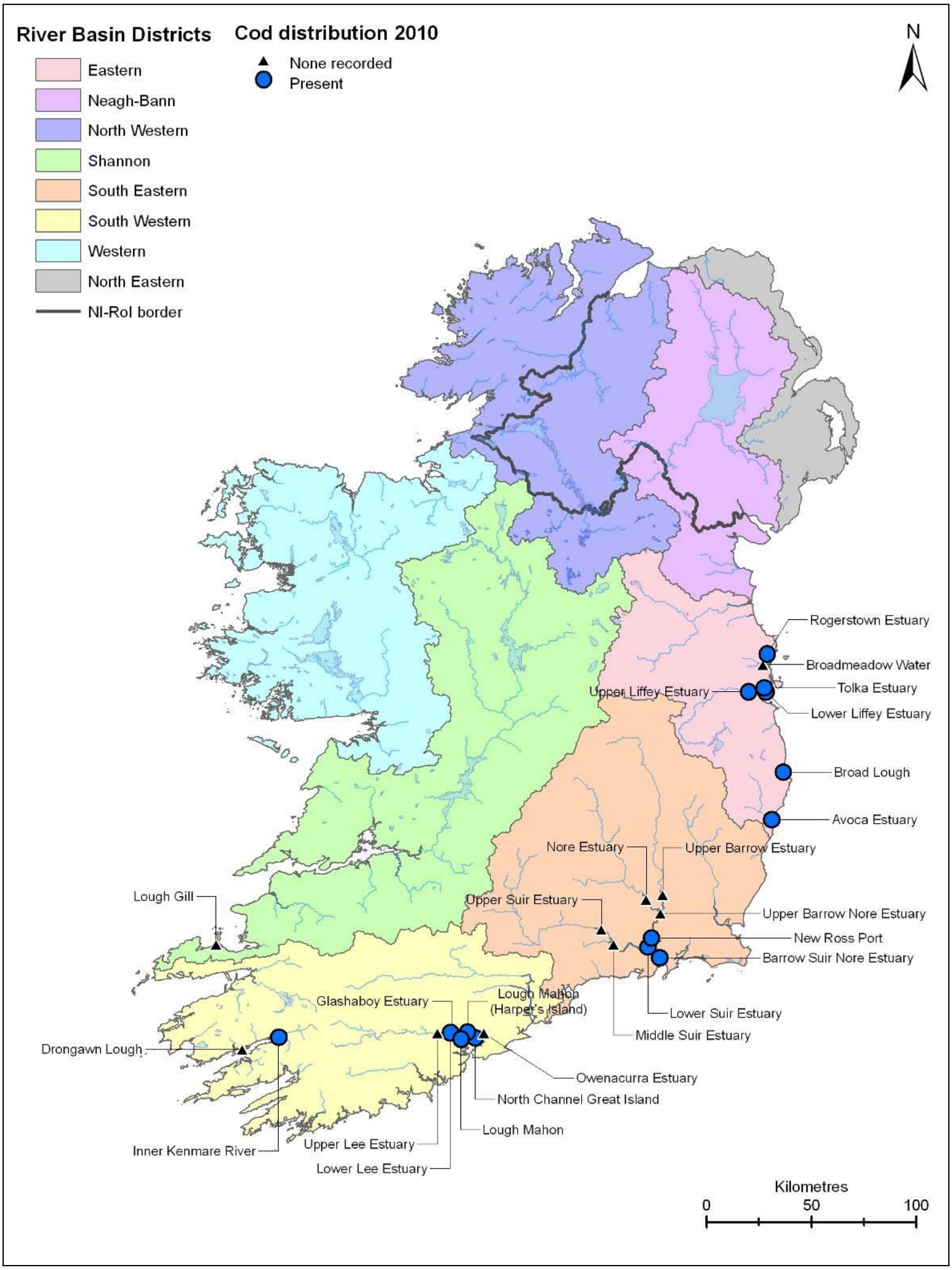

Fig. 4.88. Cod distribution in transitional waters surveyed for WFD fish monitoring 2010

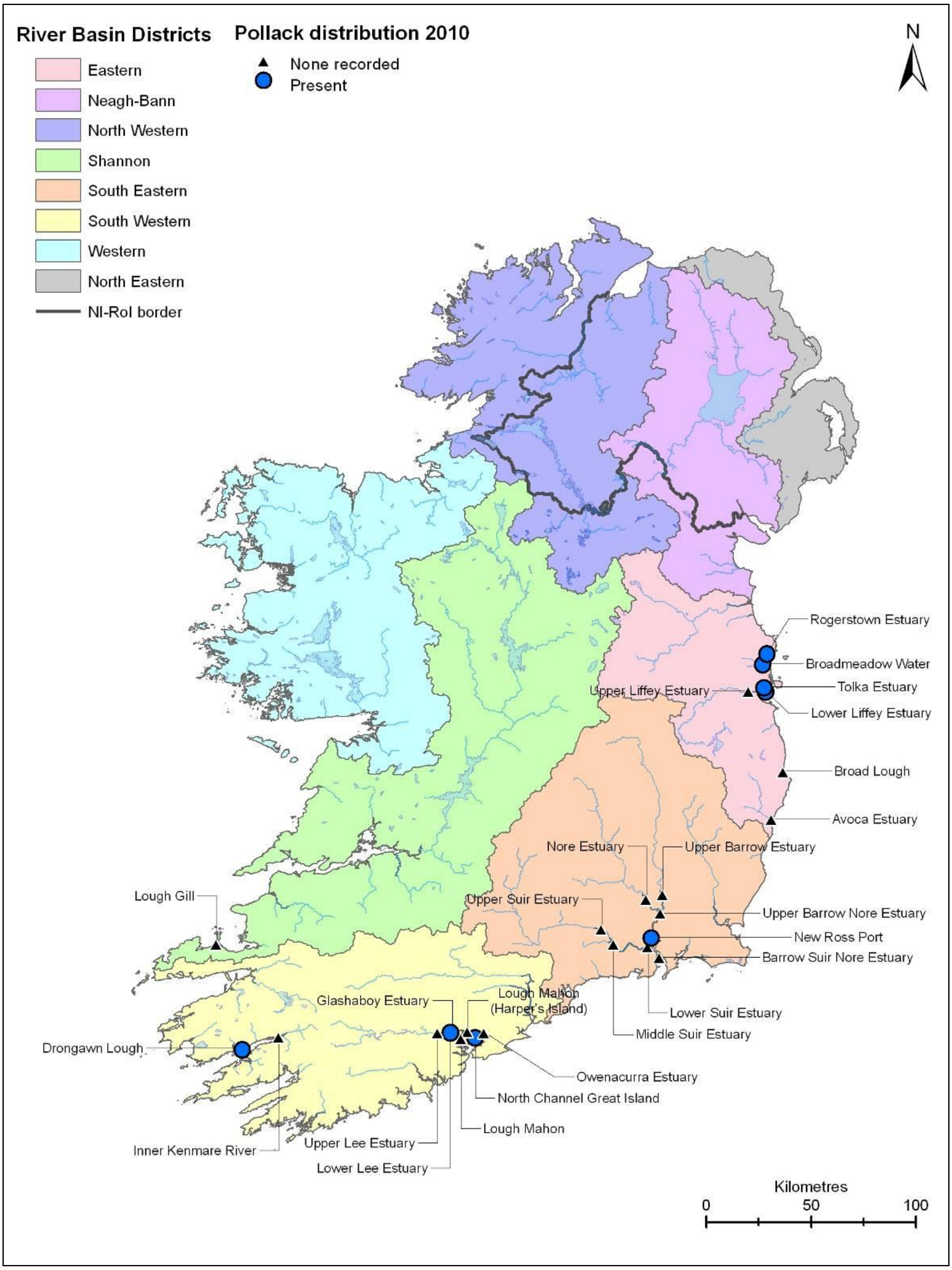

Fig. 4.89.Pollack distribution in transitional waters surveyed for WFD fish monitoring 2010

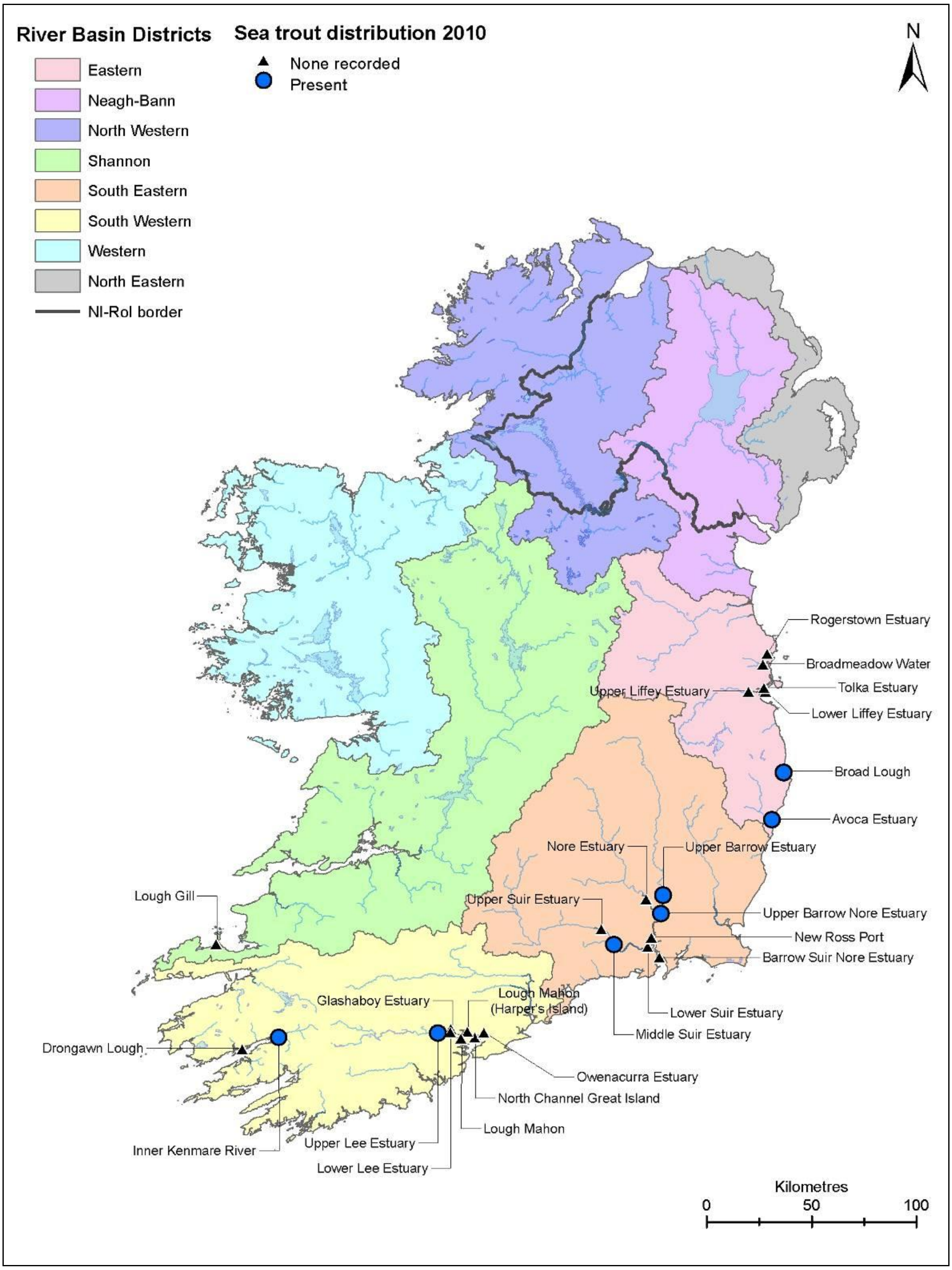

Fig. 4.90. Sea trout distribution in transitional waters surveyed for WFD fish monitoring 2010

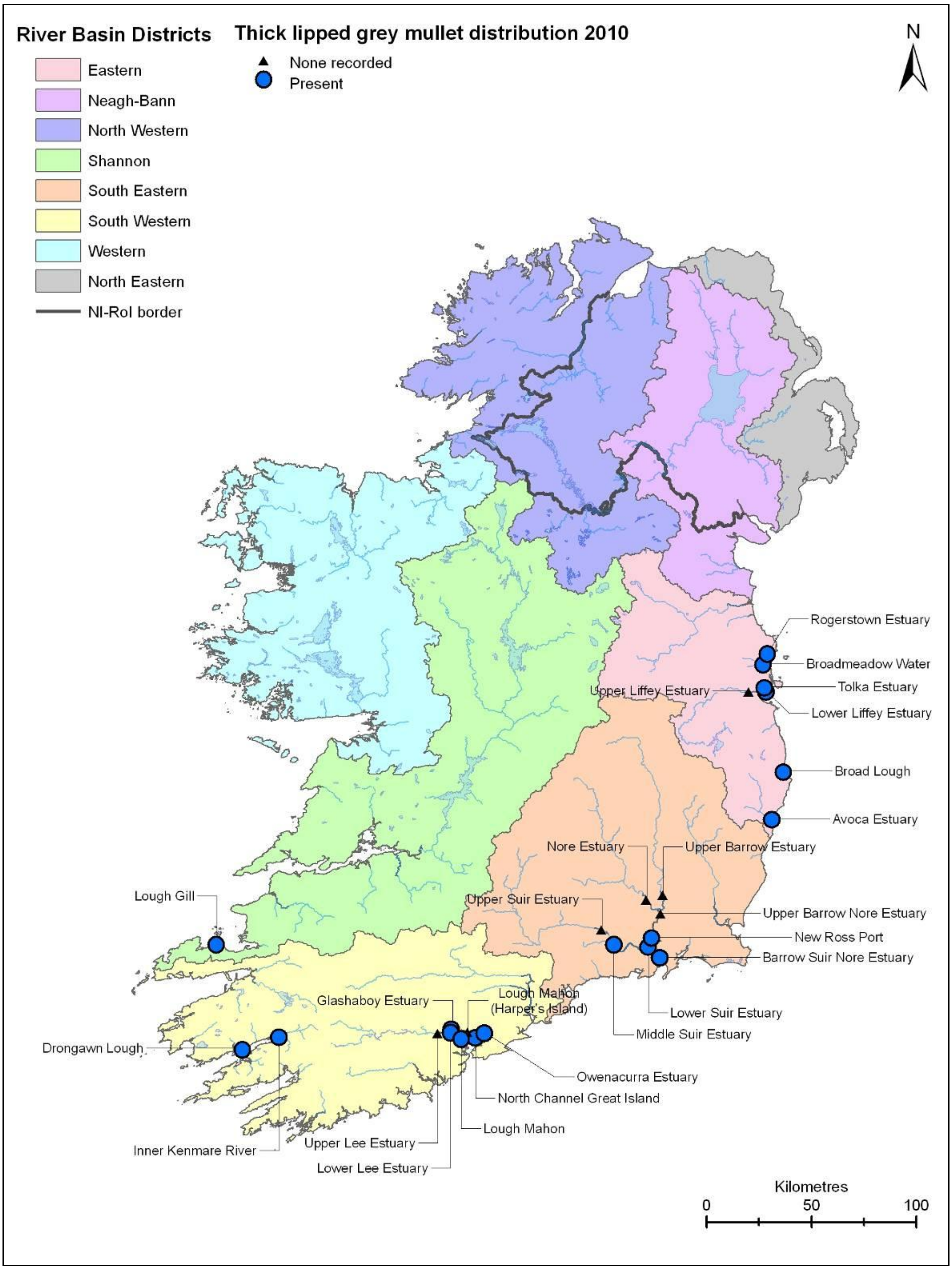

Fig. 4.91. Thick-lipped grey mullet distribution in transitional waters surveyed for WFD fish monitoring 2010

4.3.3 Ecological status - Classification of transitional waters using 'TFCI'

An essential step in the WFD monitoring process is the classification of the status of transitional waters, which in turn will assist in identifying the objectives that must be set in the individual River Basin Management Plans. IFI has completed 147 transitional water fish surveys in 81 water bodies to date (WFD and Habitats Directive data). This extremely valuable dataset of new fish population information has been amalgamated with data collected by the Northern Ireland Environment Agency (NIEA) where it has been used to develop a draft classification tool for fish in transitional waters - the 'Transitional Fish Classification Index' or TFCI. The tool uses the Index of Biotic Integrity (IBI) approach broadly based on that developed both for South African waters and the UK, with a total of ten metrics used in the index calculation. (Harrison and Whitfield, 2004; Coates *et al*., 2007).

It is not ecologically sensible to analyse all water bodies together regardless of size or freshwater influence, as species composition and abundance will vary markedly due to these two factors. As such, two water body 'types' have been identified in ROI – Transitional water bodies (fully saline estuaries, or those with minimal freshwater influence) and Lagoons/Freshwater Tidal water bodies (enclosed, usually small lagoons with low species diversity, and the upper reaches of estuaries with significant freshwater influence). Reference conditions have been defined separately for each of these two types using a combination of 'best available' data for water bodies of a similar type, along with expert opinion for metrics such as the number of indicator species expected. It is worth noting that the TFCI is still undergoing further development in order to make it fully WFD compliant, to refine the transitional water typology and type specific reference conditions; however, at this stage it has been used to provide draft ecological status classifications for each transitional water body.

Out of the 25 transitional water bodies surveyed in 2010, 19 were identified as Transitional water body types (Table 4.12). Using the TFCI, eight were classified as "Good", eight were classified as "Moderate", two were classified as "Poor" and one was classified as "Bad" (Table 4.12, Fig. 4.92).

Six water bodies were identified as Lagoon/Freshwater Tidal water body types (Table 4.12). Using the TFCI, five were classified as "Good", and one was classified as "Moderate" (Table 4.12, Fig. 4.92).

Table 4.12. Draft fish Ecological Status Classification of transitional water bodies surveyed during 2010 using the Transitional Fish Classification Index (TFCI)

Water body	Type	Ecological status
Avoca Estuary	Transitional	Moderate
Barrow Estuary, Upper	Freshwater Tidal	Good
Barrow Nore Estuary, Upper	Transitional	Moderate
Barrow Suir Nore Estuary	Transitional	Good
Broad Lough	Transitional	Good
Broadmeadow Water	Lagoon	Good
Drongawn Lough	Lagoon	Good
Gill, Lough	Lagoon	Moderate
Glashaboy Estuary	Transitional	Bad
Kenmare River, Inner	Transitional	Good
Lee (Cork) Estuary, Lower	Transitional	Poor
Lee (Cork) Estuary, Upper	Transitional	Poor
Liffey Estuary, Lower	Transitional	Moderate
Liffey Estuary, Upper	Transitional	Moderate
Mahon, Lough	Transitional	Moderate
Mahon, Lough (Harper's Island)	Transitional	Moderate
New Ross Port	Transitional	Good
Nore Estuary	Freshwater Tidal	Good
North Channel Great Island	Transitional	Good
Owenacurra Estuary	Transitional	Moderate
Rogerstown Estuary	Transitional	Good
Suir Estuary, Lower	Transitional	Good
Suir Estuary, Middle	Transitional	Moderate
Suir Estuary, Upper	Freshwater Tidal	Good
Tolka Estuary	Transitional	Good

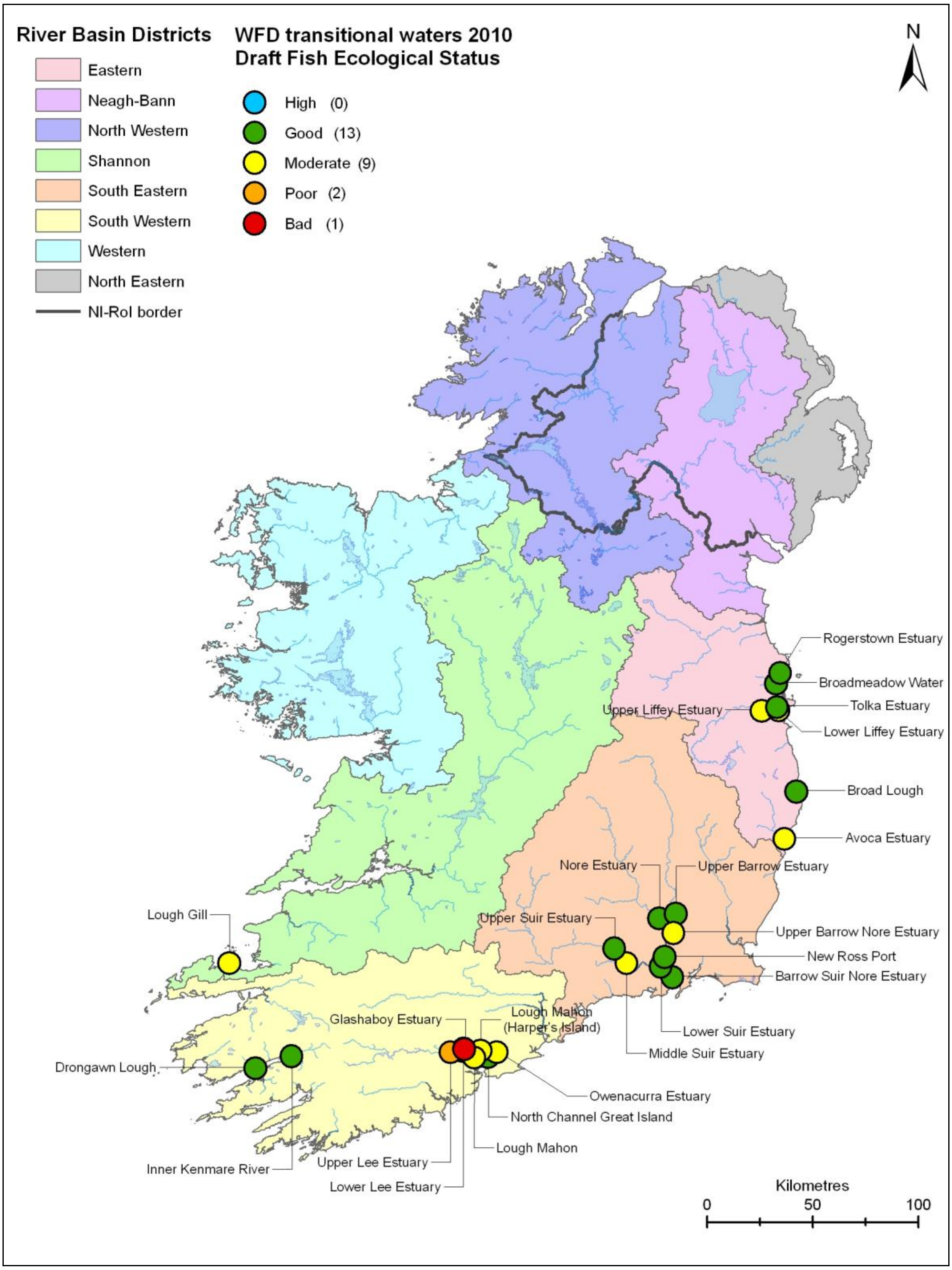

Fig. 4.92 Draft fish Ecological Status Classification of transitional water bodies surveyed during 2010 using the Transitional Fish Classification Index (TFCI)

5. DISCUSSION

5.1 Species richness

Ireland has a depauperate fish community compared with the rest of Europe. Maitland and Campbell (1992) estimate that *circa* 215 freshwater fish species occur in Europe, of which about 80 species exist in the north-western part. They identify 55 species in Britain, of which only 29 occur in Ireland. Of these 29, only 16 species are native to Ireland, with the remaining 13 species having been introduced. Some of these non-native species, such as pike (*Esox lucius*), were probably introduced in medieval times (Kelly *et al*., 2008a). Of the 16 native species, only 11 are classified as truly freshwater, with two (Twaite shad and smelt) being predominantly marine species that enter freshwater to spawn near the upstream limit of tidal influence, and three (Allis shad, sturgeon and flounder) being principally marine or estuarine species which may enter freshwater for variable periods (Kelly *et al*., 2007c; Champ *et al*., 2009).

A total of 17 fish species (sea trout are included as a separate "variety" of trout) were recorded in the 25 lakes surveyed during the 2010 WFD surveillance monitoring season. Roach x bream hybrids were also recorded. This compares with 17 fish species captured during 2008 (Kelly *et al*., 2009) and 15 fish species captured during 2009 (Kelly *et al*., 2010). Eels, followed by brown trout and perch were the three most widely distributed species recorded. The maximum number of fish species recorded in any one lake was eight (Lough Ree, ShIRBD), with a mixture of native and non-native fish species being captured in this lake.

A total of 17 fish species (sea trout are included as a separate "variety" of trout) were recorded in the 43 river sites surveyed during the 2010 WFD surveillance monitoring season. Roach x bream hybrids were also recorded. This compares with 15 fish species recorded in 2008 (Kelly *et al*., 2009) and 16 fish species recorded during 2009 (Kelly *et al*., 2010). Brown trout, eels and salmon were the most widely distributed fish species recorded. The maximum number of fish species recorded in any one river site was ten (River Blackwater at Lismore, SWRBD), again due to the presence of a mixture of native and non-native species.

A total of 55 fish species were recorded in the 25 transitional waters surveyed during the 2010 WFD surveillance monitoring season. This compares with 61 and 55 species recorded during 2008 and 2009 respectively (Kelly *et al*., 2009, Kelly *et al*., 2010). Flounder, sand goby and eels were the most widely distributed fish species, being recorded in over 85% of the sites surveyed. The maximum number of fish species recorded in any one transitional water body was 23 (North Channel Great Island, SWRBD).

5.2 Distribution of native species

Irish freshwaters were colonised after the last ice age by fish species that had the capacity to survive in saline and fresh water. These indigenous species represent the native fish fauna of the island of Ireland. The native fish community of Irish lakes and rivers in the absence of anthropogenic influences is one dominated by salmonids, including the glacial relict Arctic char *Salvelinus alpinus* (Kelly *et al*., 2007c).

Brown trout occur in almost every rivulet, brook, stream and river in Ireland (Kennedy and Fitzmaurice, 1971). This is reflected in the 2010 fish surveillance monitoring programme for rivers, in which 81% of rivers surveyed contained brown trout. Brown trout were also recorded in 80% of lakes surveyed, mainly being absent in lakes where non-native fish dominated. These values for brown trout prevalence are similar to previous work carried out in Irish lakes and rivers (Kelly *et al*., 2007a and 2007c, Kelly *et al*., 2008a and 2008b and Kelly *et al*., 2009; Kelly *et al*., 2010).

Salmon and eels occur in every water body in Ireland to which they can gain access (Moriarty and Dekker, 1997; McGinnity *et al.*, 2003). Eels were recorded in 88% of lakes and 79% of river sites. Salmon were recorded in 79% of river sites, but only 16% of lakes surveyed. This is not entirely unexpected, however, as salmon are not often captured in lake surveys due to the transient nature of their life cycle and the use of rivers as juvenile nursery habitat. Four large catchments (Shannon, Erne, Liffey and Lee) no longer have self sustaining populations of salmon and efforts are underway to restore salmon to these areas through a number of projects, for example, the Lee Restoration project (Gargan, P., IFI, *pers. comm.*) and the Atlantic Aquatic Resource Conservation Project focussing on the River Shannon (IFI website - www.fisheriesireland.ie).

Char were recorded in four lakes during 2010 (Glen Lough, Kylemore Lough, Shindilla Lough and Ardderry Lough). Although historically present in Lough Erne, no char specimens were captured in 2010, suggesting the likely local extinction of the species in this lake. A number of char populations have become extinct over the last 30 years and this has been related mainly to deterioration in water quality or acidification, for example Lough Dan (Igoe *et al.*, 2005). Water abstraction is an additional pressure which can affect the status of char populations due to the potential exposure of spawning beds (Igoe, F., ICCG, *pers. comm.*).

The absence of native species such as trout, salmon and char within specific catchments is related to various factors, including deterioration in water quality, the presence of impoundments preventing fish passage, drainage and modification of river morphology, habitat deterioration and translocation and competition from non-native species. The WFD sets out three main objectives; to preserve, protect and restore the quality of the aquatic environment. The WFD does not specifically refer to the prevention of fish passage by impoundments; however, Member States must ensure that the physical condition of surface waters (e.g. those affected by drainage schemes) supports ecological standards (SHIRBD, 2009).

5.3 Distribution of non-native fish species

The native Irish freshwater fish fauna has been augmented by a large number of non-native species (e.g. perch, pike, dace, bream, tench, roach, rainbow trout). These have been introduced either deliberately or accidentally through careless management, e.g. angling activities, aquaculture and the aquarium trade. A non-native species is one that has been either intentionally or accidentally released into an environment outside of its natural geographical habitat range (Barton and Heard, 2005). Many of these species have become established in the wild throughout Irish lakes and rivers, e.g. pike, perch, roach, rudd and bream.

Non-native fish species were present in 24 out of the 25 lakes surveyed during 2010. Overall, the majority of high alkalinity lakes (in parts of the east/midlands, west and the north-west) exhibited higher species richness than low alkalinity lakes, reflecting the presence of non-native species in these lakes. Non-native species were present in 39 out of the 43 river sites surveyed. Species richness was generally quite even throughout the country for the rivers sampled in 2010. In previous years, rivers located in the northern portion of the ShIRBD and southern part of the NWIRBD often tended to have higher species richness levels, due to the presence of non-native species (Kelly *et al*., 2009 and 2010). Non-native freshwater species were also present in seven of the 25 transitional water bodies surveyed.

Pike, perch and roach are three of the most common non-native fish species recorded in Irish waters. In 2010, these species were recorded in a cluster of lakes mainly in counties Galway, Westmeath and Cavan/Fermanagh and throughout the ShIRBD, whilst they were present in river sites mainly in the upper ShIRBD and WRBD. The Shannon-Erne Waterway facilitates the movement of non-native species between the two regions, resulting in their gradual spread. Records of these species in other catchments during 2010 were rare, however they were recorded in parts of the country with no access to the Shannon and Erne catchments (e.g. River Barrow, Munster Blackwater, Funshion River, River Lee, Ross Lake, Lough Shindilla, Ardderry Lough, Lattone Lough, Lough Lene, Lough Bane and Lough Annagh/White), providing evidence that these fish have been deliberately relocated to new catchments over the past 50 years. The Munster Blackwater was the first river in Ireland in which roach were recorded. Non-native fish recorded in the transitional water surveys included freshwater species such as dace, perch, roach and rudd captured in low salinity areas in the upper tidal limits of estuaries and in lagoons. These estuaries are typically fed by large rivers that sweep the fish downstream during flood events.

The presence of abundant populations of non-native fish species can also be an indicator of ecosystem health. Researchers have found that there are general trends for species richness, abundance and biomass of these species to increase in relation to deterioration in water quality in both lakes and rivers (Kelly *et al*., 2007a and 2007c and Kelly *et al*., 2008b). Salmonids were the dominant fish species in ultraoligo/oligotrophic lakes. This dominance decreases and changes to a population dominated by non-native fish species as trophic status increases; however, this change can only be seen in water bodies where non-native fish species are present to begin with (Kelly *et al*., 2008b).

The status of non-native species varies throughout Ireland. Data collected for the WFD to date confirms that the north-west, west and south-west are the last areas in the country to which many of these non-native species have not yet been translocated. Every effort must be made to preserve the status of the native fish populations, whilst preventing the introduction of non-native species to these areas.

The function of IFI is the conservation and protection of indigenous and naturalised fishes and to prohibit the introduction of non-native and potentially invasive species. IFI also implement regulations relating to the use of live bait and the transfer of fish between waters, adopting a proactive approach in order to minimise the potential impact of cultured fish on wild populations (Lowry, 2009).

Article 22 (b) of the EU Habitats Directive 92/43/EEC states that contracting parties shall "ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flow and, if they consider it necessary, prohibit such introduction".

5.4 Effects of non-native species on indigenous fish populations

The introduction of pike and its subsequent spread to a large proportion of the country has had an adverse effect on the indigenous salmonid populations (Fitzmaurice, 1984). Brown trout were not recorded in five lakes surveyed during 2010 (Lough MacNean Lower, Urlaur Lough, Ross Lake, Lough Atedaun and Glenade Lough). In waters where brown trout, cyprinids and perch are abundant, pike prey on brown trout in preference to other fish species (Fitzmaurice, 1984). Toner (1957) showed that 51.0% to 66.6% of pike stomachs from Lough Corrib contained trout.

Roach were present in nine out of the 25 lakes surveyed during 2010, and 16 out of the 43 river sites surveyed (mostly in the north midlands and northwest). Roach, accidentally introduced to Ireland in 1889 (Went, 1950), have been distributed to many waters, mostly by anglers (Fitzmaurice, 1981), over the last 50 years. Roach is a species which has been shown to affect salmonid production and cause a decline in brown trout angling catches (Fitzmaurice, 1984). Within a few years of being introduced into a water body they can become the dominant species due to their high fecundity. They usually displace brown trout, and rudd stocks disappear almost to the point of extinction (Fitzmaurice, 1981). Fertile hybrids between roach, bream and rudd are produced and with back crossing roach become the dominant species (Fitzmaurice, 1984; CFB, 2009a; CFB, 2009b).

Dace, introduced along with roach to the Munster Blackwater in 1889 (Went, 1950), have developed populations since 1975 in the River Nore, Co. Kilkenny and the Bunratty River, Co. Clare, a tributary of the Shannon (Moriarty and Fitzmaurice, 2000). This species has recently also been identified in the River Shannon at Castleconnell and its tributary the Mulkear River, occurring upstream and downstream of the weir at Annacotty. Dace were first recorded in the River Barrow in 1992 at St Mullins, Co. Carlow, and have since spread as far upstream as Vicarstown, Co. Kildare (Caffrey *et al*., 2007). During the 2010 WFD surveillance monitoring surveys, dace were recorded in the River's Barrow, Nore and Suir in the SERBD and River Blackwater (Lismore) and its tributary the River Funshion in the SWRBD.

Water bodies with non-native invasive fish species will not meet high status for WFD purposes due to the presence of these species. Future introductions of non-native species will also lead to a downgrading of the ecological status of a water body.

5.5 Fish age and growth

Growth of brown trout in Irish lakes has been shown to be influenced by a number of factors (Kennedy and Fitzmaurice, 1971; Everhart, 1975):

1. The types of streams in which the trout spawn and the length of time the young trout spend in them
2. The shape of the growth curve after the first three years of life
3. The age at which the trout are cropped by anglers
4. Food availability (amount and size)
5. The number of fish using the same food resource
6. Temperature, oxygen and other water quality factors

Alkalinity is also known to have an influence on the growth rate of fish in both lakes and rivers. In waters deficient in calcium, some species of molluscs, for example, cannot exist and few if any species are abundant, therefore calcium can directly affect the fauna and subsequent food availability for fish populations. In Irish lakes there appear to be few exceptions to the rule that the more alkaline the water the faster the brown trout growth rate. The average size of brown trout caught by anglers is, in general, related to the rate of growth (Kennedy and Fitzmaurice, 1971). Exceptions to this rule usually involve major differences in stock density between small lakes, with consequent differences in the amount of food available to individual fish (Kennedy and Fitzmaurice, 1971). There is some evidence to suggest that, in low alkalinity lakes, growth is faster when the conductivity is high (usually because of maritime influence) than where the conductivity is very low (Kennedy and

Fitzmaurice, 1971). Furthermore, in less productive lakes, trout are slow growing, relatively short-lived and less selective in their feeding than in richer waters.

Stock density (e.g. overstocking) can also have an effect on the growth of brown trout. In small lakes, overstocking becomes a problem, particularly if spawning facilities are extensive but food limited. A study of 14 lakes in the Rosses, Co. Donegal in 1966 demonstrated the inverse relationship between stock density and growth rate (Kennedy and Fitzmaurice, 1971).

The amount of food available is another factor which influences the rate of growth of brown trout in lakes. From a biological perspective, it is a waste of energy for fish to seek foods which are small, scarce and hard to catch (Kennedy and Fitzmaurice, 1971). If fish are to grow well they must be able to obtain large amounts of suitable food organisms of suitable sizes with the minimum of searching. This is possible when there are large standing crops of suitable foods which are never fully grazed (Kennedy and Fitzmaurice, 1969).

Age analysis of fish captured during WFD fish monitoring in 2010 demonstrated that there was a large variation in the growth of a variety of fish species amongst both lakes and rivers, with alkalinity being one of the main factors influencing growth.

The mean lengths at age of brown trout in high alkalinity lakes were generally higher than those in moderate or low alkalinity lakes (Fig. 4.41), although these results were not statistically significant, probably due to the low sample size of lakes in each alkalinity class. Surprisingly, perch in low alkalinity lakes exhibited faster growth rates than those in moderate or high alkalinity lakes (Fig. 4.42). This is the opposite of what we would expect; however, this could be due to fast growing newly introduced populations of perch in the only two lakes in the low alkalinity category (Ardderry and Shindilla). Only one lake (Lettercraffroe) in the low alkalinity category contained roach, therefore inferences on growth rates for this species between lakes of different alkalinity categories cannot be reliably made.

Brown trout in rivers exhibited similar growth patterns, with the mean lengths at age of brown trout in high alkalinity rivers generally being higher than those in moderate or low alkalinity rivers (Fig. 4.80).

In rivers, the range of salmonid age classes differed to that of lakes, reflecting the different dominant life history stages in the two water body types. Lower numbers of juvenile salmonid age classes were recorded in lakes than in rivers, as most spend one or two years in nursery streams before migrating downstream into larger rivers or lakes. Densities of both salmon and brown trout 0+ and 1+ fish were consistently higher in small wadeable streams than in deeper channels. This is mainly due to the preference for juvenile salmonids to inhabit shallow riffle areas; however, it may also be due in some part to the relative catch efficiency of bank-based electric-fishing surveys compared with boat-based electric fishing.

5.6 Ecological status classifications

An essential step in the WFD process is the classification of the status of lakes, rivers and transitional waters, which in turn will assist in identifying the objectives that must be set in the individual River Basin District Management Plans. A preliminary classification tool for fish in lakes (FIL1) was developed during the NS SHARE "Fish in Lakes" Project. This tool was designed to assign lakes in Ecoregion 17 (Ireland) to ecological status classes ranging from high to bad based on fish species composition, abundance and age structure (Kelly *et al*., 2008b). Expert opinion was also used in some occasions, where known pressures such as non-native species introductions serve to downgrade the ecological status of a lake. A high status lake, for example, cannot contain any invasive non-native species. During 2010 the "Fish in Lakes" ecological classification tool was further developed using additional data to make it fully WFD compliant; that is to define reference conditions for various lake types, assign Ecological Quality Ratio (EQR) values to each lake and provide confidence in class for the ecological classification. Expert opinion is also used on some occasions. This new classification tool will be intercalibrated with other European Member States during 2011 and used to assign lakes to ecological status classes in the future. Of the 25 lake water bodies surveyed during 2010, six lakes were assigned a draft classification of High status, eight were classified as Good status, one was classified as Moderate status and ten were classified as Poor/Bad status. The geographical variation in ecological status reflects the change in fish communities (mainly salmonids) from upland lakes with little human disturbance to the fish communities (mainly percids and cyprinids) associated with lowland lakes subject to more intensive anthropogenic pressures. Fifteen lakes classified in 2005, 2006 and 2007 using the FIL1 classification tool were again assigned status in 2010 using the new FIL2 classification tool. The ecological status remained the same for six lakes (Annagh/White Lough, Glenade Lough, Glen Lough, Glencar Lough, Maumwee Lough and Lough Shindilla) and the status improved in four lakes (Ardderry Lough, Lough Atedaun, Lough Bane and Lettercraffroe Lough) from Moderate status in 2007 to Good status in 2010. However, the status for four lakes was downgraded between 2007 and 2010 (Aughrusbeg Lough - Moderate to Poor/Bad; Lough Lene - Good to Poor/Bad; Lickeen Lough - Good to Poor/Bad; Ross Lake - Moderate to Poor/Bad; Kylemore Lough - High to Good).

An ecological classification tool for fish in rivers has recently been developed for Ecoregion 17 (Republic of Ireland and Northern Ireland), along with a separate version for Scotland to comply with the requirements of the WFD. Agencies throughout each of the three regions have contributed data which was used in the model development. It was recommended during the earlier stages of this project that an approach similar to that developed by the Environment Agency in England and Wales (Fisheries Classification Scheme 2 - 'FCS2') be used. This approach has broadly been followed and improved to develop the new classification tool – 'FCS2 Ireland'. The tool works by comparing various fish community metric values within a site (observed) to those predicted (expected) for that site under reference (un-impacted) conditions using a geo-statistical model based on Bayesian probabilities. The resultant output is an Ecological Quality Ratio (EQR) between 1 and 0, with five class boundaries defined along this range corresponding with the five ecological status classes of High, Good, Moderate, Poor and Bad. Confidence levels are assigned to each class and represented as probabilities. The tool is currently undergoing the EU intercalibration process to standardise ecological status classifications across Europe. FCS2 Ireland has been used to classify the 43 river sites surveyed during 2010; four river sites were classified as High, 17 as Good, 18 as Moderate, zero as Poor and zero as Bad. Four sites were not classified due to river conditions during the time of the survey being inappropriate for collection of reliable data.

A new preliminary WFD fish classification tool, Transitional Fish Classification Index or TCFI, has been developed for the island of Ireland (Ecoregion 1) using NIEA and IFI data. This is a multi-metric tool based on similar tools developed for transitional waters in South Africa and the UK (Harrison and Whitfield, 2004; Coates *et al.*, 2007). Out of the 25 transitional water bodies surveyed in 2010, 13 (52%) were assigned a draft ecological classification of Good status, while 12 (48%) were classified as less than Good status (9 Moderate, 2 Poor and 1 Bad). The TFCI is still under some development, particularly when considering freshwater tidal zones and lagoons. Lagoons in their nature don't have a strong connection to the ocean and thus have a different species composition when compared with other estuaries. Small estuaries also have naturally lower species richness than larger estuaries; therefore, it is difficult to compare sites of significantly different size or salinity. This is evident in the ecological classifications, where lagoons and freshwater tidal water bodies tend to score lower than transitional water bodies due to a lower abundance and reduced species richness, particularly reflected in the absence of certain functional guilds and indicator species. There may also be a geographical influence, for example, between estuaries on the north-west coast and south-east coast of Ireland. Currently, WFD classifies all transitional water bodies in Ireland into one typology and this may prove problematic for developing a robust transitional water classification tool for all estuaries. These issues will be reviewed over the coming year and the classification tool revised. The TFCI will also be intercalibrated with transitional water classification tools developed by other European Member States.

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APPENDIX 1

Biologically verified typology for lakes in the Republic of Ireland

Type	Alkalinity	Depth	Size
1	Low (<20mg/l CaCO3)	Shallow mean depth <4m (<12m)	Small <50 ha
2	Low (<20mg/l CaCO3)	Shallow (mean depth <4m(>12m)	Large >50 ha
3	Low (<20mg/l CaCO3)	Deep mean depth >4m (<12m)	Small <50 ha
4	Low (<20mg/l CaCO3)	Deep (mean depth >4m(>12m)	Large >50 ha
5	Moderate (20-100 mg/l CaCO3)	Shallow mean depth <4m (<12m)	Small <50 ha
6	Moderate (20-100 mg/l CaCO3)	Shallow (mean depth <4m(>12m)	Large >50 ha
7	Moderate (20-100 mg/l CaCO3)	Deep mean depth >4m (<12m)	Small <50 ha
8	Moderate (20-100 mg/l CaCO3)	Deep (mean depth >4m(>12m)	Large >50 ha
9	High (>100mg/l CaCO3)	Shallow mean depth <4m (<12m)	Small <50 ha
10	High (>100mg/l CaCO3)	Shallow (mean depth <4m(>12m)	Large >50 ha
11	High (>100mg/l CaCO3)	Deep mean depth >4m (<12m)	Small <50 ha
12	High (>100mg/l CaCO3)	Deep (mean depth >4m(>12m)	Large >50 ha
13	Some lakes >300m altitude		

APPENDIX 2

Presence/absence of each species captured in each lake during 2010

Lake	Three-spined stickleback	Nine-spined stickleback	Flounder	Pollan	Sea trout	Char	Salmon	Brown Trout	Eel	Minnow	Perch	Pike	Rainbow trout	Roach	Bream	Tench	Rudd	Roach x Bream
Annagh/White								x		x	x	x	x					
Ardderry					x	x		x	x		x							
Atedaun									x		x	x					x	
Aughrusbeg	x							x	x								x	
Bane		x						x	x		x	x	x					
Beltra					x		x	x	x		x							
Erne Upper								x	x		x	x		x	x			x
Glen						x	x	x	x	x								
Glenade									x		x	x		x				
Glencar	x		x		x		x	x	x	x								
Kylemore					x	x		x	x	x								
Lattone								x	x		x			x	x	x		x
Lene	x							x	x		x	x	x			x		
Lettercraffroe	x							x	x					x				
Lickeen	x							x	x								x	
MacNean Lower									x		x			x	x		x	x
MacNean Upper								x	x		x	x		x	x		x	x
Maumwee	x						x	x	x	x								
Mushlin								x			x						x	
Nambrackmore								x	x									
Rea	x	x						x	x		x	x					x	
Ree				x				x	x		x	x		x	x	x		x
Ross											x	x		x	x			x
Shindilla	x					x		x	x		x							
Urlaur									x		x	x		x				x

APPENDIX 3

Lengths at age of brown trout in 19 lakes surveyed during 2010 (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	Growth Category
Ardderry	Mean	6.9	15.0	21.3	22.3					Very slow
	n	8	8	6	1					
	S.D.	1.5	3.2	2.5	n/a					
	S.E.	0.5	1.1	1.0	n/a					
	Min.	4.8	11.1	18.5	22.3					
	Max.	8.6	19.8	25.0	22.3					
Aughrusbeg	Mean	8.4	13.1	18.9						
	n	1	1	1						
	S.D.	n/a	n/a	n/a						
	S.E.	n/a	n/a	n/a						
	Min.	8.4	13.1	18.9						
	Max.	8.4	13.1	18.9						
Bane	Mean	15.2	29.0	37.5	48.3					Very fast
	n	5	5	5	1					
	S.D.	1.9	4.2	4.3	n/a					
	S.E.	0.9	1.9	1.9	n/a					
	Min.	13.0	24.6	32.7	48.3					
	Max.	18.0	33.7	43.6	48.3					
Beltra	Mean	7.9	16.5	24.1						
	n	15	11	3						
	S.D.	1.1	3.3	3.3						
	S.E.	0.3	1.0	1.9						
	Min.	5.7	10.1	21.0						
	Max.	9.5	20.7	27.6						
Erne Upper	Mean	9.0	19.3	26.6	41.6	49.9	55.5	60.2	65.6	Very fast
	n	3	3	3	2	2	2	2	1	
	S.D.	2.5	4.5	7.0	5.9	6.0	3.5	1.1	n/a	
	S.E.	1.4	2.6	4.0	4.1	4.2	2.5	0.8	n/a	
	Min.	6.5	16.1	19.6	37.5	45.7	53.0	59.4	65.6	
	Max.	11.4	24.4	33.6	45.8	54.2	58.0	61.0	65.6	
Glen	Mean	7.4	15.7	20.7	24.8	29.2				Very slow
	n	77	72	31	8	1				
	S.D.	1.5	2.0	1.9	3.7	n/a				
	S.E.	0.2	0.2	0.3	1.3	n/a				
	Min.	5.0	11.1	16.1	21.6	29.2				
	Max.	11.8	19.1	27.3	33.0	29.2				
Nambrackmore	Mean	6.5	12.8	20.3						
	n	14	14	3						
	S.D.	1.5	2.6	4.8						
	S.E.	0.4	0.7	2.7						
	Min.	4.2	9.5	17.2						
	Max.	8.5	18.2	25.7						

APPENDIX 3 continued

Lengths at age of brown trout in 19 lakes surveyed during 2010 (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	Growth Category
Maumwee	Mean	6.6	15.1	20.0	25.6					Slow
	n	55	38	9	1					
	S.D.	1.4	2.1	1.8	n/a					
	S.E.	0.2	0.3	0.6	n/a					
	Min.	3.7	11.1	17.6	25.6					
	Max.	9.7	21.0	22.8	25.6					
Lettercraffroe	Mean	8.2	17.7	23.7	31.3	31.7				Fast
	n	33	27	8	3	2				
	S.D.	1.2	2.0	2.2	4.7	1.1				
	S.E.	0.2	0.4	0.8	2.7	0.8				
	Min.	6.5	12.5	20.5	28.2	30.9				
	Max.	11.0	23.7	27.9	36.8	32.5				
Glencar	Mean	6.1	14.4	22.2	25.6					Slow
	n	55	36	9	1					
	S.D.	1.2	1.9	3.0	n/a					
	S.E.	0.2	0.3	1.0	n/a					
	Min.	4.4	10.1	18.5	25.6					
	Max.	9.8	17.8	29.2	25.6					
Lattone	Mean	6.5	13.7	19.9	22.8					Very slow
	n	6	6	2	1					
	S.D.	0.9	1.5	0.6	n/a					
	S.E.	0.4	0.6	0.4	n/a					
	Min.	5.7	11.2	19.5	22.8					
	Max.	8.3	15.6	20.4	22.8					
Mushlin	Mean	8.0	18.4							
	n	1	1							
	S.D.	n/a	n/a							
	S.E.	n/a	n/a							
	Min.	8.0	18.4							
	Max.	8.0	18.4							
Lene	Mean	8.9	25.0	35.2						
	n	7	7	2						
	S.D.	1.5	2.3	0.4						
	S.E.	0.6	0.9	0.3						
	Min.	7.2	21.2	34.9						
	Max.	11.7	28.1	35.5						

APPENDIX 3 continued

Lengths at age of brown trout in 19 lakes surveyed during 2010 (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	Growth Category
Kylemore	Mean	6.0	12.6	19.0	22.9	27.2	37.6	76.0		Very slow
	n	41	31	16	6	4	3	1		
	S.D.	1.2	2.3	2.5	4.6	8.1	18.4	n/a		
	S.E.	0.2	0.4	0.6	1.9	4.1	10.6	n/a		
	Min.	3.6	9.3	14.8	19.9	21.5	26.4	76.0		
	Max.	8.5	16.9	23.5	31.9	39.2	58.8	76.0		
Shindilla	Mean	5.7	12.9	17.6	20.3					Very slow
	n	22	9	3	1					
	S.D.	1.5	2.4	2.1	n/a					
	S.E.	0.3	0.8	1.2	n/a					
	Min.	4.1	10.2	16.2	20.3					
	Max.	8.9	16.8	19.9	20.3					
Lickeen	Mean	7.9	18.4	26.3						
	n	34	25	3						
	S.D.	1.4	3.1	2.5						
	S.E.	0.2	0.6	1.4						
	Min.	5.2	12.8	23.5						
	Max.	9.9	23.7	28.2						
MacNean Upper	Mean	6.9	17.5							
	n	2	2							
	S.D.	1.1	0.4							
	S.E.	0.8	0.3							
	Min.	6.1	17.3							
	Max.	7.7	17.8							
Rea	Mean	8.7	22.2	31.2						
	n	6	4	1						
	S.D.	1.9	2.1	n/a						
	S.E.	0.8	1.1	n/a						
	Min.	6.5	20.8	31.2						
	Max.	11.6	25.4	31.2						
Ree	Mean	6.5	13.5	22.2	31.0	42.5				Fast
	n	8	7	5	2	1				
	S.D.	2.1	3.4	5.9	2.5	n/a				
	S.E.	0.7	1.3	2.6	1.8	n/a				
	Min.	4.6	9.8	17.3	29.2	42.5				
	Max.	11.2	18.4	31.5	32.8	42.5				

APPENDIX 4

Lengths at age of perch in 17 lakes surveyed during 2010 (L1=back calculated length of perch at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
Ardderry	Mean	7.8	16.3	20.5	22.6	26.0						
	n	67	52	29	13	1						
	S.D.	1.6	2.1	1.6	1.5	n/a						
	S.E.	0.2	0.3	0.3	0.4	n/a						
	Min.	5.5	13.0	18.3	19.8	26.0						
	Max.	11.2	20.6	23.7	25.3	26.0						
Bane	Mean	5.9	11.6	19.0	25.3	28.3	33.8	35.6				
	n	61	30	23	10	5	1	1				
	S.D.	1.1	3.1	2.7	2.3	3.2	n/a	n/a				
	S.E.	0.1	0.6	0.6	0.7	1.5	n/a	n/a				
	Min.	4.0	6.8	15.2	21.4	23.7	33.8	35.6				
	Max.	9.3	17.9	24.2	28.8	32.0	33.8	35.6				
Beltra	Mean	5.3	10.5	13.6	15.5	16.6	18.2	19.9				
	n	53	53	40	23	9	6	4				
	S.D.	0.6	1.0	1.3	1.6	2.3	2.0	2.5				
	S.E.	0.1	0.1	0.2	0.3	0.8	0.8	1.3				
	Min.	4.2	7.7	10.8	12.5	13.0	16.0	17.1				
	Max.	7.1	12.8	16.5	18.2	19.5	21.0	22.8				
Erne Upper	Mean	5.2	9.4	14.8	19.3	22.7	25.4	26.2				
	n	107	85	62	47	16	9	3				
	S.D.	0.7	1.5	2.5	2.9	2.6	2.7	3.3				
	S.E.	0.1	0.2	0.3	0.4	0.7	0.9	1.9				
	Min.	3.3	6.4	8.2	12.1	16.7	20.4	23.6				
	Max.	7.4	14.6	20.5	24.2	26.5	28.3	29.9				
Urlaur	Mean	4.7	9.3	14.2	18.0	20.8	21.3					
	n	116	91	73	39	13	7					
	S.D.	0.7	1.4	2.0	2.3	2.3	2.8					
	S.E.	0.1	0.1	0.2	0.4	0.6	1.1					
	Min.	2.5	5.6	8.5	13.4	15.7	16.4					
	Max.	6.4	13.9	18.3	25.9	23.9	24.7					
Atedaun	Mean	6.7	11.5	15.8	19.7	25.0						
	n	50	32	13	4	1						
	S.D.	1.1	1.3	2.0	2.9	n/a						
	S.E.	0.2	0.2	0.6	1.5	n/a						
	Min.	4.9	9.3	13.4	17.0	25.0						
	Max.	10.1	14.6	20.3	22.8	25.0						
Annagh/White	Mean	6.3	11.1	17.8								
	n	39	20	1								
	S.D.	1.1	1.5	n/a								
	S.E.	0.2	0.3	n/a								
	Min.	4.1	7.4	17.8								
	Max.	8.3	13.3	17.8								

APPENDIX 4 continued

Lengths at age of perch in 17 lakes surveyed during 2010 (L1=back calculated length of perch at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
Lattone	Mean	5.3	10.2	12.8	14.7	16.4	17.8	20.9	21.7	23.7	24.6	27.4
	n	65	53	47	39	23	14	6	5	4	3	2
	S.D.	0.7	1.3	1.3	1.5	1.5	1.9	3.4	2.9	2.3	0.9	2.1
	S.E.	0.1	0.2	0.2	0.2	0.3	0.5	1.4	1.3	1.2	0.5	1.5
	Min.	3.3	6.5	8.9	10.2	13.6	15.3	16.3	18.3	22.3	23.6	26.0
	Max.	6.5	12.3	15.1	18.1	18.7	21.8	26.2	25.7	27.2	25.2	28.9
Glenade	Mean	4.8	9.2	12.2	14.6	15.6	17.3	18.9				
	n	65	53	43	35	19	11	5				
	S.D.	0.7	1.1	1.4	1.8	1.4	1.6	1.7				
	S.E.	0.1	0.2	0.2	0.3	0.3	0.5	0.7				
	Min.	3.4	6.0	9.0	11.5	12.7	14.3	16.8				
	Max.	6.8	11.8	16.2	19.2	18.1	19.2	21.0				
Mushlin	Mean	5.6	10.8	14.4	16.7	19.3	20.5	22.3	24.1			
	n	61	45	36	33	8	5	3	1			
	S.D.	0.6	1.0	1.1	1.2	1.8	1.7	0.6	n/a			
	S.E.	0.1	0.2	0.2	0.2	0.6	0.8	0.3	n/a			
	Min.	4.3	9.2	12.0	14.6	16.5	18.5	21.9	24.1			
	Max.	7.2	12.7	17.3	20.0	21.7	23.0	23.0	24.1			
Lene	Mean	5.8	12.1	17.1	20.4	22.5	24.4					
	n	143	120	99	70	36	9					
	S.D.	0.8	1.4	1.7	1.8	2.0	2.2					
	S.E.	0.1	0.1	0.2	0.2	0.3	0.7					
	Min.	4.2	8.5	12.2	15.0	17.4	21.1					
	Max.	9.1	16.6	20.7	24.6	27.9	28.9					
Shindilla	Mean	6.9	14.9	21.4	24.1	27.0	27.6					
	n	22	19	5	5	2	1					
	S.D.	1.4	3.0	1.0	2.0	0.1	n/a					
	S.E.	0.3	0.7	0.4	0.9	0.1	n/a					
	Min.	3.1	6.7	20.0	21.0	27.0	27.6					
	Max.	9.7	18.7	22.5	25.8	27.1	27.6					
MacNean Lower	Mean	5.1	8.8	13.1	16.1	18.1	19.4					
	n	64	47	30	21	10	2					
	S.D.	0.6	0.9	1.7	2.7	2.5	1.1					
	S.E.	0.1	0.1	0.3	0.6	0.8	0.8					
	Min.	4.0	6.9	9.8	11.3	15.6	18.6					
	Max.	6.3	11.1	17.3	20.7	24.2	20.2					
MacNean Upper	Mean	5.2	9.0	13.0	16.0	18.5	20.0	22.2	21.7	20.7		
	n	106	85	74	54	35	28	17	3	1		
	S.D.	0.7	1.1	1.7	2.0	2.2	2.2	2.0	1.9	n/a		
	S.E.	0.1	0.1	0.2	0.3	0.4	0.4	0.5	1.1	n/a		
	Min.	3.3	6.9	9.8	11.8	13.9	15.7	18.5	20.0	20.7		
	Max.	7.1	11.7	17.3	20.1	22.5	23.2	25.1	23.7	20.7		

APPENDIX 4 continued

Lengths at age of perch in 17 lakes surveyed during 2010 (L1=back calculated length of perch at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
Ross	Mean	5.7	9.5	13.0	15.8	18.7	21.1	20.8				
	n	67	55	40	32	10	3	1				
	S.D.	0.9	1.5	1.7	2.0	3.3	1.6	n/a				
	S.E.	0.1	0.2	0.3	0.4	1.1	0.9	n/a				
	Min.	3.1	5.4	8.5	11.1	13.2	19.3	20.8				
	Max.	7.6	13.0	17.0	20.8	24.5	22.4	20.8				
Rea	Mean	5.8	12.4	18.5	23.2	24.6	26.2	30.1				
	n	114	87	48	27	7	6	5				
	S.D.	1.0	1.7	1.7	2.0	2.7	2.6	3.5				
	S.E.	0.1	0.2	0.2	0.4	1.0	1.1	1.5				
	Min.	3.7	8.5	12.7	19.1	21.1	23.0	26.3				
	Max.	8.6	16.7	21.6	27.0	29.3	29.4	33.5				
Ree	Mean	5.6	10.7	15.8	19.7	22.4	24.1	26.1	27.9			
	n	122	94	72	56	40	27	8	2			
	S.D.	0.9	1.8	2.2	2.4	2.4	2.7	2.4	2.4			
	S.E.	0.1	0.2	0.3	0.3	0.4	0.5	0.9	1.7			
	Min.	3.4	6.8	11.0	15.6	17.0	19.2	21.2	26.2			
	Max.	7.9	17.4	22.1	25.7	26.4	29.4	29.3	29.6			

APPENDIX 5

Lengths at age of roach in 9 lakes surveyed during 2010 (L1=back calculated length of roach at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
Erne Upper	Mean	3.6	7.8	12.4	16.4	20.3	23.0	24.3	25.1	27.6					
	n	83	77	62	56	32	17	8	3	1					
	S.D.	0.7	1.3	1.8	2.2	2.0	2.0	2.2	2.1	n/a					
	S.E	0.1	0.1	0.2	0.3	0.4	0.5	0.8	1.2	n/a					
	Min.	2.3	5.2	7.2	11.6	15.6	18.9	20.8	22.8	27.6					
	Max.	5.2	10.8	17.0	20.1	24.0	26.4	28.5	26.8	27.6					
Urlaur	Mean	3.6	8.0	13.2	17.8	21.6	24.0	26.0	27.5	29.5					
	n	93	85	61	48	30	13	7	6	1					
	S.D.	0.9	1.5	1.7	2.1	1.9	1.3	1.3	1.5	n/a					
	S.E.	0.1	0.2	0.2	0.3	0.3	0.3	0.5	0.6	n/a					
	Min.	2.3	5.9	10.0	13.5	19.0	22.1	24.4	25.7	29.5					
	Max.	6.3	12.0	16.9	22.2	25.9	25.7	28.2	29.9	29.5					
Lettercraffroe	Mean	2.8	9.1	15.5	19.4	22.1	23.1	24.7	25.7	27.0					
	n	48	34	34	34	29	1	1	1	1					
	S.D.	0.5	1.0	1.6	1.7	1.7	n/a	n/a	n/a	n/a					
	S.E.	0.1	0.2	0.3	0.3	0.3	n/a	n/a	n/a	n/a					
	Min.	2.1	6.9	12.1	16.1	19.5	23.1	24.7	25.7	27.0					
	Max.	4.1	10.9	18.4	23.1	25.4	23.1	24.7	25.7	27.0					
Glenade	Mean	3.7	10.2	16.8	21.4	25.3	28.7								
	n	92	83	54	44	13	3								
	S.D.	0.5	0.9	1.4	1.8	1.6	0.6								
	S.E.	0.1	0.1	0.2	0.3	0.4	0.4								
	Min.	2.7	6.8	12.5	16.3	21.7	28.3								
	Max.	5.1	11.9	20.1	25.2	27.9	29.5								
MacNean Lower	Mean	3.1	7.1	11.1	14.2	16.5	18.0								
	n	36	36	33	22	15	2								
	S.D.	0.7	1.0	1.1	1.3	1.2	0.4								
	S.E.	0.1	0.2	0.2	0.3	0.3	0.3								
	Min.	2.1	5.7	8.3	10.5	14.3	17.8								
	Max.	5.0	9.4	13.1	16.4	19.4	18.3								
MacNean Upper	Mean	3.1	6.5	10.4	13.6	16.4	18.5	19.8	22.2	23.2	25.1				
	n	43	43	43	34	22	10	4	3	1	1				
	S.D.	0.5	1.1	1.1	1.2	1.0	1.6	1.2	0.6	n/a	n/a				
	S.E.	0.1	0.2	0.2	0.2	0.2	0.5	0.6	0.3	n/a	n/a				
	Min.	2.2	4.0	8.4	10.7	14.6	16.9	18.5	21.5	23.2	25.1				
	Max.	4.1	9.1	12.8	16.2	18.4	21.7	21.4	22.7	23.2	25.1				

APPENDIX 5 continued

Lengths at age of roach in 9 lakes surveyed during 2010 (L1=back calculated length of roach at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
Ross	Mean	3.3	6.7	10.6	13.7	16.2	18.4	21.0	26.3	29.3					
	n	70	69	55	39	26	20	10	1	1					
	S.D.	0.4	0.9	1.3	1.4	1.6	1.6	2.0	n/a	n/a					
	S.E	0.1	0.1	0.2	0.2	0.3	0.4	0.6	n/a	n/a					
	Min.	2.1	4.6	7.5	11.5	13.7	15.8	18.6	26.3	29.3					
	Max.	4.5	8.6	13.8	17.8	20.8	22.2	24.3	26.3	29.3					
Lattone	Mean	3.2	7.9	12.1	16.4	21.7	23.1	24.7	25.7	27.0					
	n	1	1	1	1	1	1	1	1	1					
	S.D.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					
	S.E.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					
	Min.	3.2	7.9	12.1	16.4	21.7	23.1	24.7	25.7	27.0					
	Max.	3.2	7.9	12.1	16.4	21.7	23.1	24.7	25.7	27.0					
Ree	Mean	3.8	8.6	13.5	17.8	20.8	23.1	24.5	26.3	27.7	29.1	30.0	30.7	31.1	31.4
	n	83	80	80	71	53	37	25	21	21	19	15	9	6	3
	S.D.	0.8	1.7	2.5	2.8	2.7	2.8	2.4	2.4	2.5	2.3	1.9	2.0	2.1	1.8
	S.E.	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.8	1.0
	Min.	2.2	5.5	8.3	12.4	15.4	17.5	19.6	22.2	23.4	24.9	25.9	27.5	28.5	29.5
	Max.	5.9	13.4	18.7	24.0	25.5	28.5	29.2	30.9	32.7	34.7	32.2	32.9	33.3	33.0

APPENDIX 6

Output from the FIL2 ecological classification tool

Lake	FIL2 Typology	EQR	EQR Lower 95% C.I.	EQR Upper 95% C.I.	EQR Classification	DA Classification
Beltra	4	0.920	0.736	0.980	High	Good
Maumwee	1	0.874	0.827	0.909	High	High
Glen	1	0.872	0.813	0.914	High	Good
Glencar	4	0.850	0.491	0.971	High	High
Shindilla	2	0.818	0.694	0.899	High	Good
Nambrackmore	1	0.764	0.675	0.835	High	Good
Lettercraffroe	2	0.753	0.614	0.854	Good	Good
Ardderry	1	0.724	0.598	0.822	Good	High
Macnean Upper	2	0.722	0.598	0.819	Good	Good
Kylemore	2	0.634	0.475	0.768	Good	Moderate
Rea	4	0.629	0.246	0.898	Good	Good
Atedaun	3	0.625	0.490	0.743	Good	Good
Bane	3	0.613	0.508	0.708	Good	Moderate
Annagh/White Lough	4	0.589	0.272	0.847	Good	High
Glenade	3	0.340	0.277	0.411	Moderate	Good
Erne Upper	3	0.268	0.213	0.333	Poor/Bad	Moderate
Ree	4	0.233	0.066	0.566	Poor/Bad	Moderate
Ross (Corrib)	3	0.224	0.149	0.323	Poor/Bad	Good
Mushlin	3	0.156	0.070	0.312	Poor/Bad	High
Macnean Lower	1	0.147	0.096	0.217	Poor/Bad	Moderate
Urluar	3	0.098	0.071	0.134	Poor/Bad	Poor/Bad
Lattone	1	0.085	0.044	0.160	Poor/Bad	Poor/Bad
Lickeen	2	0.033	0.007	0.146	Poor/Bad	Poor/Bad
Lene	4	0.029	0.003	0.245	Poor/Bad	Poor/Bad
Aughrusbeg	1	0.021	0.010	0.044	Poor/Bad	Poor/Bad

APPENDIX 7

Lengths at age of brown trout in 35 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	Growth category
Abbert	Mean	6.7	10.7			Very slow
	S.D.	1.6	n/a			
	S.E.	0.4	n/a			
	n	18	1			
	Min	3.3	10.7			
	Max	8.8	10.7			
Aherlow	Mean	7.9	14.5	19.7	20.4	Slow
	S.D.	2.2	3.0	3.5	3.1	
	S.E.	0.3	0.4	0.6	1.6	
	n	70	57	30	4	
	Min	3.8	8.8	13.9	15.9	
	Max	12.7	20.7	26.2	23.0	
Ara	Mean	8.9	16.4	21.6		Slow
	S.D.	1.8	3.6	1.7		
	S.E.	0.2	0.6	1.0		
	n	94	39	3		
	Min	4.1	10.1	19.7		
	Max	13.1	21.4	23.1		
Avonbeg	Mean	5.7	10.8	14.4		Very slow
	S.D.	0.7	1.5	n/a		
	S.E.	0.2	0.8	n/a		
	n	12	3	1		
	Min	4.5	9.9	14.4		
	Max	7.0	12.5	14.4		
Ballydangan	Mean	9.0	14.4	22.4	31.9	Fast
	S.D.	1.3	3.2	3.3	5.2	
	S.E.	0.5	1.6	1.9	3.0	
	n	6	4	3	3	
	Min	7.0	10.7	18.6	25.9	
	Max	10.6	18.2	25.0	35.2	
Ballysadare	Mean	9.5	20.9	25.9		Fast
	S.D.	1.6	3.1	n/a		
	S.E.	0.5	1.4	n/a		
	n	12	5	1		
	Min	7.4	17.8	25.9		
	Max	12.4	25.1	25.9		
Blackwater (Nohaval)	Mean	8.2	16.1	21.1		Slow
	S.D.	1.9	2.7	2.2		
	S.E.	0.2	0.5	1.1		
	n	57	32	4		
	Min	4.8	8.7	19.0		
	Max	13.7	20.7	23.9		

APPENDIX 7 continued

Lengths at age of brown trout in 35 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	Growth category
Bonet	Mean	8.1	13.9	21.0		Slow
	S.D.	n/a	n/a	n/a		
	S.E.	n/a	n/a	n/a		
	n	1	1	1		
	Min	8.1	13.9	21.0		
	Max	8.1	13.9	21.0		
Boyne	Mean	7.3	14.6	19.8	24.2	Slow
	S.D.	1.4	3.5	1.9	0.1	
	S.E.	0.2	0.6	0.7	0.1	
	n	50	32	8	2	
	Min	4.5	9.0	16.0	24.1	
	Max	10.1	19.9	22.8	24.3	
Clare Corrofin	Mean	10.4				n/a
	S.D.	n/a				
	S.E.	n/a				
	n	1				
	Min	10.4				
	Max	10.4				
Clare (Kiltroge)	Mean	8.3	18.8	31.2		Very fast
	S.D.	2.1	4.6	n/a		
	S.E.	0.5	1.6	n/a		
	n	15	8	1		
	Min	4.7	11.0	31.2		
	Max	11.6	23.4	31.2		
Cullies	Mean	8.9	15.7			Slow
	S.D.	1.5	n/a			
	S.E.	0.7	n/a			
	n	4	1			
	Min	8.1	15.7			
	Max	11.2	15.7			
Cummeragh	Mean	4.8				n/a
	S.D.	0.8				
	S.E.	0.3				
	n	10				
	Min	3.7				
	Max	6.0				
Dalua	Mean	7.2	14.2	18.3		Slow
	S.D.	1.9	2.2	n/a		
	S.E.	0.4	0.8	n/a		
	n	21	7	1		
	Min	4.4	10.1	18.3		
	Max	12.5	16.6	18.3		

APPENDIX 7 continued

Lengths at age of brown trout in 35 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	Growth category
Fane	Mean	7.3	16.2	22.5	26.7	Fast
	S.D.	1.2	3.2	1.2	0.1	
	S.E.	0.2	0.6	0.4	0.1	
	n	49	30	9	2	
	Min	4.6	10.3	20.8	26.6	
	Max	10.0	20.9	24.5	26.7	
Finisk	Mean	8.8	17.9			Fast
	S.D.	0.8	n/a			
	S.E.	0.3	n/a			
	n	8	1			
	Min	7.6	17.9			
	Max	9.9	17.9			
Funshion	Mean	6.8	14.6	20.7		Slow
	S.D.	1.6	2.8	2.1		
	S.E.	0.3	0.6	0.7		
	n	30	21	9		
	Min	4.5	9.7	18.2		
	Max	10.6	19.0	23.4		
Gowran	Mean	9.1	17.3			Fast
	S.D.	1.4	1.0			
	S.E.	0.3	0.6			
	n	18	3			
	Min	6.5	16.1			
	Max	11.5	18.0			
Lee (Inchinossig)	Mean	7.7	14.2	21.0		Slow
	S.D.	1.4	2.1	n/a		
	S.E.	0.3	0.9	n/a		
	n	19	5	1		
	Min	4.4	11.2	21.0		
	Max	9.8	16.7	21.0		
Lee (Leemount Br.)	Mean	7.0	16.0	21.8		Slow
	S.D.	2.2	6.2	n/a		
	S.E.	0.9	4.4	n/a		
	n	6	2	1		
	Min	4.6	11.5	21.8		
	Max	10.8	20.4	21.8		
Licky	Mean	7.1	13.2			Slow
	S.D.	1.6	1.8			
	S.E.	0.3	0.6			
	n	25	8			
	Min	3.4	10.3			
	Max	10.0	15.1			

APPENDIX 7 continued

Lengths at age of brown trout in 35 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	Growth category
Moy (Bleanmore)	Mean	8.2	14.6	21.7		Slow
	S.D.	2.0	3.0	n/a		
	S.E.	0.7	1.7	n/a		
	n	8	3	1		
	Min	4.5	11.2	21.7		
	Max	10.0	16.9	21.7		
Moy (Cloonbaniff)	Mean	7.1	13.3			Slow
	S.D.	1.6	2.1			
	S.E.	0.3	0.7			
	n	26	8			
	Min	3.6	10.8			
	Max	10.0	17.2			
Moy (Gweestion)	Mean	7.3	14.2	19.5	24.3	Slow
	S.D.	1.7	2.7	1.7	2.2	
	S.E.	0.2	0.5	0.5	1.6	
	n	49	34	12	2	
	Min	4.1	9.4	16.1	22.7	
	Max	10.9	19.6	22.7	25.9	
Nore (Brownsbarn)	Mean	7.4	15.3	20.5	24.3	Slow
	S.D.	1.5	2.6	4.0	n/a	
	S.E.	0.3	0.5	1.1	n/a	
	n	33	31	12	1	
	Min	3.6	8.8	13.1	24.3	
	Max	9.8	20.8	26.8	24.3	
Nore (Quakers')	Mean	8.0	15.8	21.1		Slow
	S.D.	1.4	1.3	n/a		
	S.E.	0.3	0.5	n/a		
	n	18	6	1		
	Min	5.7	14.4	21.1		
	Max	10.9	18.2	21.1		
Owenmore (Sligo)	Mean	7.8	16.7	25.5		Fast
	S.D.	1.9	3.3	0.8		
	S.E.	0.4	0.9	0.6		
	n	19	14	2		
	Min	3.3	11.9	25.0		
	Max	10.5	24.6	26.1		
Owenreagh	Mean	4.2	14.7	21.1		Slow
	S.D.	0.7	1.3	n/a		
	S.E.	0.4	0.8	n/a		
	n	4	3	1		
	Min	3.5	13.8	21.1		
	Max	5.3	16.2	21.1		

APPENDIX 7 continued

Lengths at age of brown trout in 35 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	Growth category
Owenriff	Mean	5.5	14.6	22.1		Slow
	S.D.	1.2	n/a	n/a		
	S.E.	0.6	n/a	n/a		
	n	4	1	1		
	Min	4.2	14.6	22.1		
	Max	6.6	14.6	22.1		
Owvane (Cork)	Mean	6.7	12.6			Very slow
	S.D.	1.3	3.8			
	S.E.	0.6	2.7			
	n	4	2			
	Min	5.0	9.9			
	Max	7.9	15.3			
Robe	Mean	6.6	18.0	20.6		Fast
	S.D.	2.2	1.4	n/a		
	S.E.	1.3	0.8	n/a		
	n	3	3	1		
	Min	4.6	16.6	20.6		
	Max	9.0	19.4	20.6		
Slaney	Mean	6.0	12.2	19.1		Slow
	S.D.	1.3	1.2	n/a		
	S.E.	0.2	0.4	n/a		
	n	32	10	1		
	Min	3.6	10.8	19.1		
	Max	9.4	14.8	19.1		
Suir (Kilsheelan)	Mean	8.3	14.9	22.4		Fast
	S.D.	2.2	4.4	0.5		
	S.E.	0.6	1.8	0.4		
	n	14	6	2		
	Min	4.8	10.0	22.0		
	Max	10.9	22.0	22.8		
Suir (Knocknageragh)	Mean	8.0	17.8	22.3	25.9	Fast
	S.D.	1.8	3.3	3.9	4.4	
	S.E.	0.2	0.6	2.0	3.1	
	n	62	27	4	2	
	Min	4.2	10.3	16.5	22.8	
	Max	12.5	23.0	25.1	29.0	

APPENDIX 8

Lengths at age of salmon in 29 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4
Abbert	Mean	4.6	7.3		
	S.D.	1.6	0.7		
	S.E.	0.3	0.3		
	n	25	7		
	Min	2.2	6.4		
	Max	7.4	8.4		
Aherlow	Mean	5.8	9.7		
	S.D.	1.2	n/a		
	S.E.	0.2	n/a		
	n	26	1		
	Min	3.5	9.7		
	Max	9.2	9.7		
Ara	Mean	6.3	7.7		
	S.D.	1.2	n/a		
	S.E.	0.2	n/a		
	n	25	1		
	Min	3.4	7.7		
	Max	8.6	7.7		
Avonbeg	Mean	4.6	9.0		
	S.D.	1.1	0.1		
	S.E.	0.2	0.1		
	n	19	2		
	Min	3.3	8.9		
	Max	7.6	9.1		
Ballysadare	Mean	5.3			
	S.D.	1.2			
	S.E.	0.2			
	n	34			
	Min	2.8			
	Max	8.1			
Blackwater (Lismore)	Mean	5.0	12.1	41.8	36.2
	S.D.	1.2	1.7	20.5	n/a
	S.E.	0.2	1.2	14.5	n/a
	n	32	2	2	1
	Min	2.8	10.9	27.3	36.2
	Max	7.8	13.4	56.2	36.2
Blackwater (Nohaval)	Mean	5.1	9.1		
	S.D.	1.2	0.0		
	S.E.	0.2	0.0		
	n	25	2		
	Min	3.2	9.1		
	Max	7.0	9.1		

APPENDIX 8 continued

Lengths at age of salmon in 29 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4
Bonet River	Mean	4.4			
	S.D.	n/a			
	S.E.	n/a			
	n	1			
	Min	4.4			
	Max	4.4			
Clare (Corrofin)	Mean	5.3			
	S.D.	1.1			
	S.E.	0.2			
	n	22			
	Min	2.8			
	Max	7.8			
Clare (Kiltroge)	Mean	5.3	39.4		
	S.D.	1.0	n/a		
	S.E.	0.2	n/a		
	n	25	1		
	Min	3.5	39.4		
	Max	7.0	39.4		
Cummeragh	Mean	4.4			
	S.D.	1.0			
	S.E.	0.2			
	n	23			
	Min	2.9			
	Max	6.7			
Dalua	Mean	4.7	8.9		
	S.D.	1.0	0.8		
	S.E.	0.2	0.3		
	n	29	7		
	Min	2.5	8.1		
	Max	6.9	10.3		
Fane	Mean	4.2	8.1		
	S.D.	0.8	0.7		
	S.E.	0.1	0.2		
	n	28	10		
	Min	3.3	7.3		
	Max	5.9	9.3		
Finisk	Mean	5.5	10.0		
	S.D.	1.1	n/a		
	S.E.	0.2	n/a		
	n	30	1		
	Min	3.6	10.0		
	Max	8.0	10.0		

APPENDIX 8 continued

Lengths at age of salmon in 29 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4
Funshion	Mean	5.2			
	S.D.	1.2			
	S.E.	0.2			
	n	27			
	Min	3.2			
	Max	7.9			
Gowran	Mean	5.9	8.9		
	S.D.	1.4	n/a		
	S.E.	0.3	n/a		
	n	20	1		
	Min	2.5	8.9		
	Max	8.5	8.9		
Lee (Leemount Br.)	Mean	5.0			
	S.D.	0.7			
	S.E.	0.3			
	n	5			
	Min	4.1			
	Max	5.7			
Licky	Mean	5.5			
	S.D.	1.3			
	S.E.	0.4			
	n	10			
	Min	4.0			
	Max	7.9			
Moy (Bleanmore)	Mean	4.2	7.1		
	S.D.	0.8	0.8		
	S.E.	0.2	0.5		
	n	20	3		
	Min	2.8	6.2		
	Max	5.7	7.8		
Moy (Cloonbaniff)	Mean	4.6			
	S.D.	1.7			
	S.E.	0.7			
	n	6			
	Min	2.6			
	Max	7.2			
Moy (Gweestion)	Mean	4.4	7.4		
	S.D.	1.0	0.5		
	S.E.	0.2	0.2		
	n	25	6		
	Min	2.4	7.0		
	Max	7.0	8.1		

APPENDIX 8 continued

Lengths at age of salmon in 29 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4
Nore (Brownsbarn)	Mean	4.8	8.1		
	S.D.	1.1	n/a		
	S.E.	0.2	n/a		
	n	24	1		
	Min	3.0	8.1		
	Max	7.3	8.1		
Owenmore (Sligo)	Mean	5.4	9.2		
	S.D.	1.2	2.0		
	S.E.	0.2	1.4		
	n	35	2		
	Min	2.9	7.8		
	Max	7.4	10.6		
Owenreagh	Mean	4.1	7.1		
	S.D.	0.8	0.6		
	S.E.	0.2	0.4		
	n	20	2		
	Min	2.7	6.7		
	Max	5.4	7.5		
Owenriff	Mean	3.9	7.6	14.1	
	S.D.	1.1	1.6	1.8	
	S.E.	0.2	0.5	1.3	
	n	25	12	2	
	Min	2.6	4.8	12.8	
	Max	6.5	10.5	15.4	
Owvane (Cork)	Mean	4.7	8.5		
	S.D.	1.0	n/a		
	S.E.	0.2	n/a		
	n	17	1		
	Min	3.4	8.5		
	Max	6.7	8.5		
Slaney	Mean	4.7	8.6		
	S.D.	0.9	0.4		
	S.E.	0.2	0.1		
	n	33	8		
	Min	3.5	8.0		
	Max	7.2	9.2		
Suir (Kilsheelan)	Mean	5.6	9.8		
	S.D.	1.2	n/a		
	S.E.	0.2	n/a		
	n	27	1		
	Min	3.3	9.8		
	Max	7.6	9.8		

APPENDIX 8 continued

Lengths at age of salmon in 29 rivers surveyed during 2010 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4
Suir (Knocknageragh)	Mean	6.8			
	S.D.	0.5			
	S.E.	0.2			
	n	5			
	Min	6.3			
	Max	7.5			

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