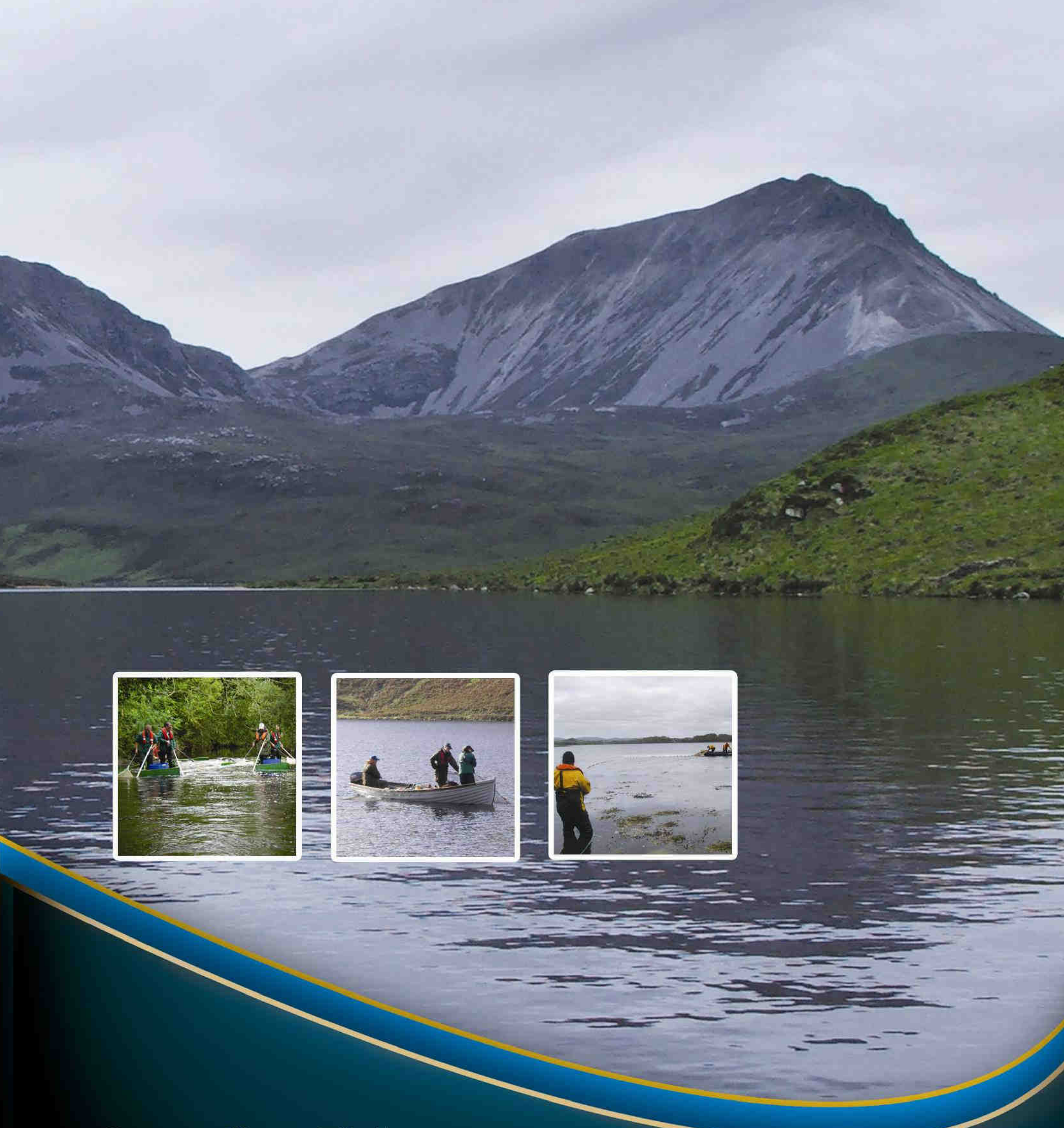

Sampling Fish for the Water Framework Directive - Summary Report 2009

The Central and Regional Fisheries Boards

Sampling Fish for the Water Framework Directive

A Summary of the Central Fisheries Board's Surveillance Monitoring for Fish in Lakes, Rivers and Transitional Waters 2009

Summary Report 2009

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 work closely with colleagues within Inland Fisheries Ireland (IFI - previously the Central and Regional Fisheries Boards) and with staff from other national agencies, academic institutions and our parent Department, the Department of Communication, Energy and Natural Resources.

During 2009, an extremely wet summer similar to the previous year again hampered scheduled fieldwork, particularly in river sites; however, despite this, 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 Regional Fisheries Boards during 2009, it would not have been possible to complete many of the key objectives reported in this document. With the amalgamation of the Central and Regional Fisheries Boards in July 2010 into the newly formed entity, IFI, we are pleased to be able to further the WFD work programme at a national inland fisheries level.

I would like to congratulate all who have contributed to the significant level of work which was undertaken in 2009 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 2010.

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Dr Ciaran Byrne
CEO, Inland Fisheries Ireland

August 2010

Foreword

Welcome to the Central and Regional Fisheries Boards (CFB & RFBs) Sampling Fish for the Water Framework Directive – Summary Report 2009.

The Central Fisheries Board has been assigned the responsibility by the Environmental Protection Agency (EPA) for delivering the fish monitoring element of the WFD in Ireland. Surveillance monitoring takes place over a three year rolling period, with the first three year cycle completed in 2009. Surveillance monitoring sites are set out in the WFD Monitoring Programme published by the EPA in 2006 and the fish monitoring requirements include 73 lakes, 70 transitional waters and 180 river sites. Although the surveillance monitoring programme for rivers and transitional waters was delayed by one year, the two subsequent years have seen a huge effort by the team of scientists within the Central and Regional Fisheries Boards to achieve the three year goals, and I'm delighted to report a total of 70 lakes, 68 transitional waters and 137 river sites have been surveyed in the first surveillance monitoring cycle.

The 2009 fish surveillance monitoring programme has been extensive, with 23 lakes, 23 transitional waters and 54 river sites surveyed, and approximately 68,000 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, CFB WFD staff spent the winter months processing this large volume of fish samples.

All water bodies surveyed have been assigned an interim 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 in this first cycle 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 2010. The huge amount of data generated has been collated and a new GIS database has been developed to store and display this information.

It is important that I acknowledge the support and expertise received from our colleagues in the Regional Fisheries Boards (RFBs) during the 2009 monitoring season. It is only with a coordinated effort between the CFB and RFBs that delivery of such a comprehensive monitoring programme is possible.

2010 has seen the merger of the Central and Regional Fisheries Boards into a national fishery research and management organisation called Inland Fisheries Ireland. This organisational change, within a challenging economic climate, will necessitate 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,
August 2010

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, which is completed in a three year rolling cycle. The Central and Regional Fisheries Boards (CFB and RFBs) have been assigned the responsibility by the EPA of delivering the fish monitoring requirements of the WFD in Ireland. The first three year surveillance monitoring cycle (2007 – 2009) included fish surveys in 73 lakes, 70 transitional waters and 180 river sites. In 2009, a comprehensive fish surveillance monitoring programme was conducted, with 54 river sites, 23 lakes and 23 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 2009 surveillance monitoring programme and highlights the current status of each water body in accordance with the fish populations present.

Twenty-three lakes were surveyed during 2009, with a total of 14 fish species being recorded. Sea trout and roach x bream hybrids were also recorded. Water chemistry samples, secchi depth and dissolved oxygen/temperature profiles were also taken at each lake to aid in the development of the ecological classification tool for fish in lakes which is currently being refined to make it fully WFD compliant. Eels were the most common fish species recorded, being found in all lakes surveyed. This was followed by brown trout, pike and perch which were present in 69.6%, 60.9% and 56.5% of lakes respectively. In general, salmonids dominated lakes in the north-west, west, south-west and eastern areas and were absent from lakes in the Monaghan, Clare and Shannon regions. Char were recorded in four lakes in the North Western and Western River Basin Districts; Kindrum Lough, Lough Sessiagh, Doo Lough and Lough Mask. Pike, followed by perch were the most widely distributed non-native species recorded during the 2009 surveillance monitoring programme, with pike being present in 14 and perch being present in 13 out of the 23 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.

One of the key requirements of the WFD is the classification of water bodies into ecological status classes of High, Good, Moderate, Poor or Bad. An ecological classification tool for fish in lakes has been 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). Using this tool, along with expert opinion, all lakes surveyed in 2009 have been assigned a draft ecological status based on the fish populations present; two were classified as High, eight were classified as Good, 12 were classified as Moderate and one was classified as Poor. The NWIRBD, SWRBD and ERBD were dominated by lakes classified as High or Good ecological status, with a gradual progression to Moderate, Poor and Bad ecological status lakes as we move through the SHIRBD and NBIRBD. This reflects the change in fish communities from upland lakes with little human disturbance (mainly salmonids) to the fish communities associated with lowland lakes subject to more intensive anthropogenic pressures (mainly percids and cyprinids).

A total of 54 river sites were surveyed during 2009 using boat-based electric-fishing gear for the larger sites and hand-set electric-fishing gear for the smaller sites. Fifteen fish species were recorded, along with sea trout and roach x bream hybrids. Species richness ranged from 12 in the River Barrow site to only one species in the Feorish River site.

Brown trout were the most common species recorded, being present in 93% of sites surveyed, followed by eels (80%), salmon (76%) and stoneloach (52%). 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 inhabitat 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. Similar to distribution patterns in 2008, sea trout were only recorded in sites close to the coast, and eels were generally recorded in greater densities in these sites. 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.

No ecological classification tool currently exists for fish in Irish rivers; however a model is currently being developed for Ireland (North and South) and Scotland under the management of the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER). Once completed, all Irish surveillance monitoring river sites will be assigned an ecological status class using this tool.

Twenty-three transitional water bodies were surveyed during 2009, split into three categories based on their salinity and connectivity to the sea; Transitional (12), Freshwater Tidal (2) and Lagoons (9). A total of 55 fish species were recorded, along with sea trout. Species richness among the sites surveyed ranged from 32 in Swilly Estuary (Transitional) to only two in Muree Lough (Lagoon). Eel was the most common fish species, being recorded in 96% of sites surveyed. This was followed by flounder (87%), sand goby (78%) and 3-spined stickleback (74%). Commercially important species such as cod and plaice were both recorded in 57% of transitional water bodies. Four species of angling importance were recorded; flounder (20 water bodies), pollack (10 water bodies), sea trout (7 water bodies) and thick-lipped grey mullet (9 water bodies).

A new ecological classification tool (Transitional Fish Classification Index – TFCI) for fish in transitional waters is being developed for the Island of Ireland (Ecoregion 17) using IFI and Northern Ireland Environment Agency (NIEA) data. Using TFCI, all 23 transitional waters surveyed in 2009 were assigned a draft ecological status class. One water body was classified as High, nine were classified as Good, 11 were classified as Moderate, one was classified as Poor and one was classified as Bad.

In addition to the Water Framework Directive requirements of information on ecological status, the work conducted in 2009 provides more comprehensive information on fish stocks in a large number of Irish surface waters. 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, Mr Glen Wightman, Ms. Emma Morrissey, Ms. Roisin O'Callaghan, Mr. Rory Feeney, Ms. Grainne Hanna, Ms. Ciara Wogerbauer, Mr. Kieran Rocks, Mr Trevor Stafford and Mr Brian Hayden, Central Fisheries Board (CFB), under the direction of Dr. Cathal Gallagher, Director of Research and Development as part of the Water Framework Directive (WFD) Fish Surveillance Monitoring Programme, 2007 to 2009.

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The authors wish to gratefully acknowledge the help and co-operation of the CEOs, ACEOs and their staff from the seven Regional Fisheries Boards (Eastern Regional Fisheries Board, Shannon Regional Fisheries Board, Northern Regional Fisheries Board, North-Western Regional Fisheries Board, Southern Regional Fisheries Board, South-Western Regional Fisheries Board and the Western Regional Fisheries Board). The authors would also like to gratefully acknowledge the help and cooperation from all their colleagues in the Central Fisheries Board.

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The authors would also like to acknowledge the funding provided for the project from the Department of Communication, Energy and Natural resources (DCENR) for 2009.

About the Central and Regional Fisheries Boards

The Central Fisheries Board (CFB) is a statutory body with responsibility for inland fisheries and sea angling operating under the aegis of the Department of Communications, Energy and Natural Resources and was established under the Fisheries Act 1980.

The principal functions of the CFB are to advise the Minister for Communications, Energy and Natural Resources on policy relating to the conservation, protection, management, development and improvement of inland fisheries and sea angling, to support, co-ordinate and provide specialist services to the Regional Fisheries Boards, and to advise the Minister on the performance by the Regional Fisheries Boards of their functions.

The Boards mission is to "ensure that the valuable resources of inland fisheries and sea angling are conserved, managed, developed and promoted in their own right and to support sustainable economic activity, job creation and recreational amenity".

The seven Regional Fisheries Boards have primary responsibility for fisheries management in their Regions. The role of the Regional Fisheries Boards is to conserve, protect, develop manage and promote inland fisheries. The Boards are also responsible for developing and promoting sea angling and protecting molluscs.

Inland Fisheries Ireland

The fisheries service in Ireland is currently undergoing a major organisational transition. This follows the recent 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).

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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 standard approach for all countries 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 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. The WFD is being administered and managed at local level by River Basin Districts (RBDs). In accordance with national legislation, the Environmental Protection Agency published, in 2006, a programme of monitoring to be carried out in Ireland in order to meet the legislative requirements of the WFD.

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 and 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, monitoring then helps to track the effectiveness of measures needed to clean up water bodies and achieve good status.

Water quality in Ireland has been assessed for many years by the Environmental Protection Agency (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 the Central and Regional Fisheries Boards (now IFI). A national fish stock surveillance monitoring programme has been initiated at specified locations in a 3 year rolling cycle. 73 lakes, 180 sites in rivers and 70 estuaries are being surveyed for fish in the first three year cycle. This research 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.

The Fisheries Boards began surveillance monitoring for the WFD, assisted by fishery owners and angling clubs, during 2007. During this initial period 15 lakes in 4 Regional Fisheries Board areas were successfully surveyed. Transitional waters in the Barrow, Nore and Suir estuaries and Waterford Harbour were also surveyed. No rivers were surveyed during the 2007 surveillance monitoring period.

In 2008, 32 lakes, 83 rivers and 42 transitional waters in seven Regional Fisheries Board areas were successfully surveyed assisted by fishery owners and angling clubs.

The WFD fish surveillance monitoring programme in 2009 has again been extensive and 54 river sites, 23 lakes and 23 transitional water bodies were successfully surveyed nationwide. A team of scientists from the Research and Development section of the Central Fisheries Board carried out the monitoring surveys in conjunction with the Regional Fisheries Boards. As many as four Central and Regional Fisheries Board WFD monitoring teams were deployed simultaneously to work in the field. 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. Sampling in rivers was frustrated by poor weather, higher than average rainfall and water levels. Due to the stresses of inclement weather, along with a reduction in staffing levels and resources, the surveying and monitoring of some river sites planned for 2009 have been deferred until 2010.

This report summarises the main findings of the fish stock surveys in all water bodies (lakes, rivers and transitional waters) surveyed during 2009 and reports the current status of the fish stocks in each. The previous Water Framework Directive summary report (Kelly *et al*., 2009) separated water bodies into groups based on the seven different RFBs. However; with the transition from the CFB and RFBs to IFI, the current report reflects the changes in administrative boundaries and water bodies are grouped according to RBDs.

One of the main objectives of the WFD monitoring programme is to assign ecological status to each water body and results from selected lakes and transitional waters 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-three lake water bodies, ranging in size from 8.0ha (Lough Caum) to 11650.5ha (Lough Derg), were surveyed between June and October 2009. The selection of lakes surveyed encompassed a range of lake types (11 WFD designated typologies) (EPA, 2005; Appendix 1) and trophic levels, and were distributed throughout five different RBDs (Table 2.1, Fig. 2.1).

Two lakes were surveyed in the Eastern River Basin District (ERBD) (Lough Dan and Lough Tay). Seven lakes were surveyed in the Shannon International River Basin District (ShIRBD), ranging in size from 8.0ha (Lough Caum) to 11650.5ha (Lough Derg). One lake (Lough Muckno) was surveyed in the Neagh-Bann International River Basin District (NBIRBD). Seven lakes were surveyed in the North Western International River Basin District (NWIRBD), ranging in size from 15.2ha (Lough Nasnahida) to 156.0ha (Lough Anure), and six lakes were surveyed in the Western River Basin District (WRBD), ranging in size from 16.2ha (Doo Lough) to 8217.8ha (Lough Mask). Summary details of all lakes surveyed in 2009 are shown in Table 2.1.

Table 2.1. List of lakes surveyed for WFD surveillance monitoring, June to October 2009. Details of area (ha), mean depth (m) and max depth (m) are included

Lake name	Water body code	Catchment	Easting	Northing	WFD Typology	Area (ha)	Mean depth (m)	Max depth (m)
ERBD								
Dan	EA_10_29	Avoca	315394	203430	4	102.9	13.5	40.0
Tay	EA_10_25	Avoca	316085	207508	3	50.0	10.1	35.0
ShIRBD								
Derg	SH_25_191a	Shannon Lwr	177812	185798	12	11650.5	6.0	36.0
Alewnaghta	SH_25_189	Shannon Lwr	176089	191267	6	54.6	<4.0	4.5
Cullaun	SH_27_115	Fergus	131594	190644	11	49.7	6.7	21.0
Dromore	SH_27_82	Fergus	134517	185851	11	49.1	5.9	20.0
Inchicronan	SH_27_126	Fergus	139500	185948	10	116.7	<4.0	18.8
Cam	SH_23_74	Owencashla	59744	107907	5	8.0	2.7	15.0
Gur	SH_24_99	Shannon Est Sth	163885	140815	10	78.9	2.4	5.0
NBIRBD								
Muckno	NB_06_56	Fane	285627	318883	1	316.0	5.9	20.0
NWIRBD								
Anure	NW_38_83	Coastal	181476	414670	2	156.0	2.0	11.9
Dunglow	NW_38_692	Coastal	177887	411252	2	61.0	1.3	7.5
Kindrum	NW_38_670	Coastal	217786	442631	8	61.0	6.6	15.0
Muckanagh	SH_27_100	Fergus	137228	192888	10	96.1	3.0	19.0
Nasnahida	NW_38_67	Owenamarve	185231	407764	1	15.2	<4.0	11.0
Sessiagh	NW_38_61	Coastal	203933	435931	7	24.0	4.0	20.9
White	NW_36_647	Erne	267964	319078	6	54.0	<4.0	6.0
WRBD								
Bunny	WE_27_114	Kinvarra	137409	196784	10	102.9	2.7	14.0
Arrow	WE_35_159	Ballysadare	179161	312139	12	1247.0	9.0	33.0
Cullin	WE_34_406a	Moy	122875	302769	10	1023.6	<4.0	3.0
Mask	WE_30_665	Corrib	110027	264594	12	8217.8	5.0	57.0
Carra	WE_30_347	Corrib	118998	272737	10	1564.5	1.8	19.0
Doo	WE_32_463	Owenerk	83461	268222	4	16.2	>4.0	46.0

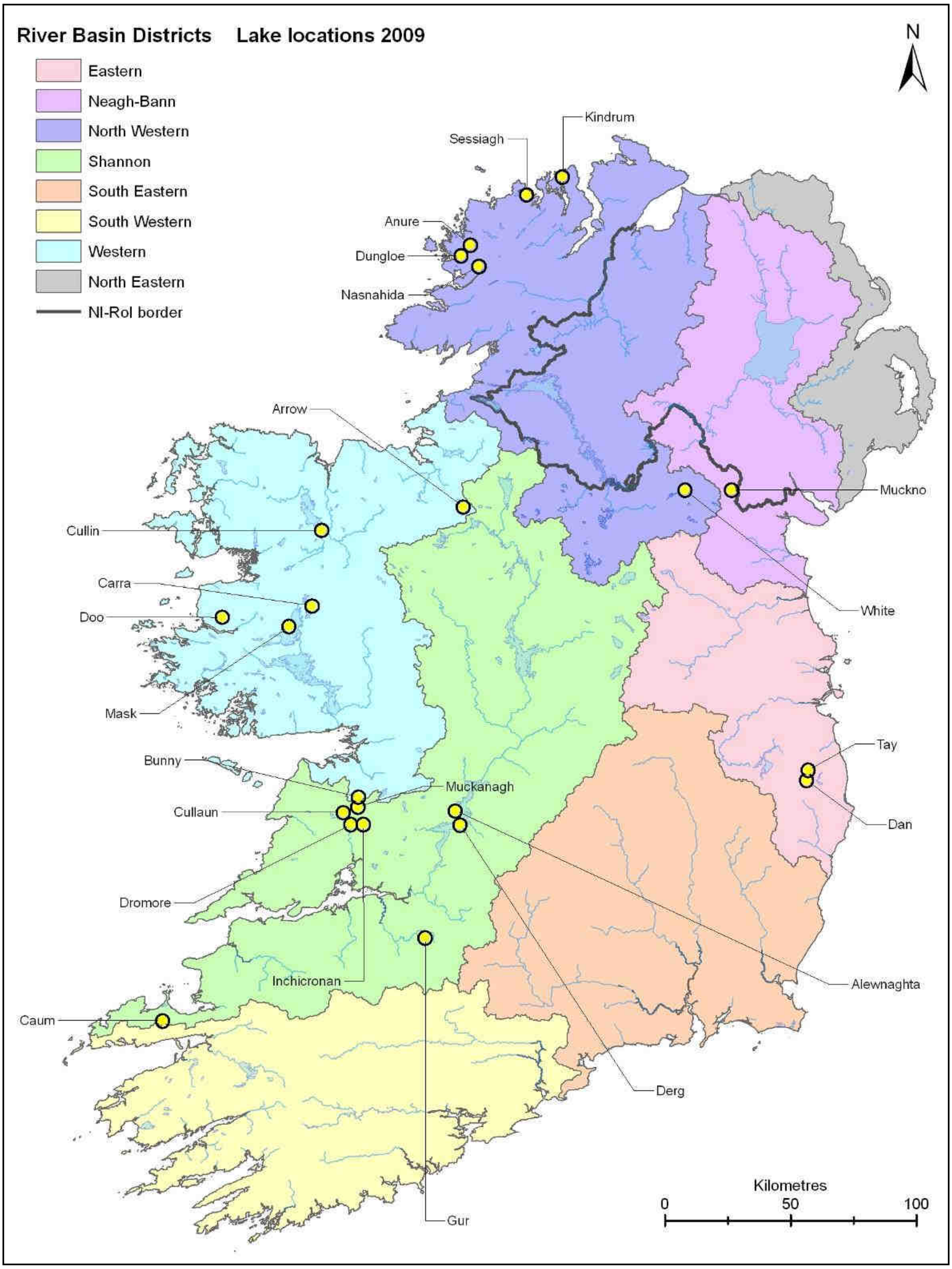

Fig. 2.1. Location map indicating the 23 lake water bodies surveyed as part of the WFD fish surveillance monitoring programme, June to October 2009

2.2 Rivers

Fifty-two river sites, ranging in surface area from 118m^2 (Glendine River, Clare) to 34738m^2 (Shannon at Ballyleague), were surveyed between July and early October 2009. 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).

Nine river sites were surveyed in the ERBD. Sites ranged in surface area from 266m^2 (Athboy River) to 1102.06m^2 (River Liffey, Lucan). Three river sites were surveyed in the NBIRBD, ranging in area from 184m^2 (Big River) to 1050m^2 (River Dee). Three river sites were surveyed in the NWIRBD; these ranged in area from 417m^2 (Clady River) to 3615m^2 (River Erne). Seven sites were sampled in the South Eastern River Basin District (SERBD), ranging from 188m^2 on the Burren River to 10906m^2 on the River Barrow. Sixteen sites were surveyed in the ShIRBD, ranging in surface area from 118m^2 on the Glendine River to 34738m^2 on the River Shannon. Seven sites were surveyed in the South Western River Basin District (SWRBD). Sites ranged in size from 405m^2 on the Funshion River to 21840m^2 on the River Blackwater (Killavullen). Seven sites were surveyed in the Western River Basin District, ranging in area from 270m^2 on the Black River to 727m^2 on the River Nanny (Tuam).

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 WFD surveillance monitoring, 2009

River	Site name	Catchment	Site Code	Water body code
ERBD Hand-set sites				
Athboy	Bridge at Clonleasan House	Boyne	IE07A010100	EA_07_971
Blackwater	Just u/s of Lough Ramor	Boyne	IE07B010800	EA_07_1035
Dargle	1km u/s of Bray Br.	Dargle	IE10D010250	EA_10_1275
Glencree	Bridge u/s of Dargle R. confl.	Dargle	IE10G010200	EA_10_367
Glenealo	Bridge d/s of Upper Lake	Avoca	IE10G050200	EA_10_793
Nanny	Bridge at Julianstown	Nanny	IE08N010700	EA_08_814
ERBD Boat sites				
Boyne	Boyne Br.	Boyne	IE07B040200	EA_07_990
Liffey	d/s of Ballyward Br.	Liffey	IE09L010250	EA_09_1175
Liffey	Lucan Br.	Liffey	IE09L012100	EA_09_1870_5
NBIRBD Hand-set sites				
Big	Ballygoly Br.	Piedmont	IE06B010100	NB_06_642
White	Coneyburrow Br.	Dee	IE06W010500	NB_06_550
NBIRBD Boat sites				
Dee	Burley Br.	Dee	IE06D010600	NB_06_50
NWIRBD Hand-set sites				
Clady	Bridge u/s of Bunbeg	Clady	IE38C040300	NW_38_4124
NWIRBD Boat sites				
Erne	Bellahillan Br.	Erne	IE36E011100	NW_36_1746
Finn	Cumber Br.	Erne	IE36F010500	XB_36_east_3
SERBD Hand-set sites				
Burren	Ullard Br.	Barrow	IE14B050100	SE_14_1781
Greese	Bridge NE of Belan House	Barrow	IE14G040350	SE_14_946
Tully Stream	Soomeragh Br.	Barrow	IE14T020390	SE_14_842
SERBD Boat sites				
Barrow	Pass Br.	Barrow	IE14B011000	SE_14_196_1
Dinin	Dinin Br.	Nore	IE15D020800	SE_15_1955
King's	Kells Br.	Nore	IE15K020800	SE_15_1819
Slaney	Waterloo Br.	Slaney	IE12S020400	SE_12_1524

Table 2.2 ctn. Location and codes of river sites surveyed for WFD surveillance monitoring, 2009

River	Site name	Catchment	Site Code	Water body code
ShIRBD Hand-set sites				
Ballyfinboy	Bridge u/s Lough Derg	Shannon Lower	IE25B020800	SH_25_1853
Bilboa	Bilboa Br.	Shannon Lower	IE25B030080	SH_25_486
Broadford	Bridge u/s of Doon Lough	Bunratty	IE27B020800	SH_27_287
Caher	Bridge 2 km d/s of Formoyle	Caher	IE28C010200	SH_28_106
Dead	Pope's Br.	Shannon Lower	IE25D010100	SH_25_1893
Glendine	Knockloskeraun Br.	Annagh	IE28G020200	SH_28_231
Moyree	Bridge u/s Fergus River	Fergus	IE27M020700	SH_27_1178
Newport	Rockvale Br.	Shannon Lower	IE25N020200	SH_25_320
Owvane	Bridge u/s of Loghill	Shannon Estuary South	IE24O020200	SH_24_878
Owveg	Owveg Br.	Feale	IE23O050200	SH_23_1743
Tyshe	West of Ardfert Friary	Tyshe	IE23T020400	SH_23_427
ShIRBD Boat sites				
Creegh	Drumellihy Br.	Creegh	IE28C021400	SH_28_709
Feorish	Bridge 1.5km SW of Keadue	Shannon Upper	IE26F020400	SH_26_234
Fergus	Poplar Br.	Fergus	IE27F010100	SH_27_181
Nenagh	Ballysoilshaun Br.	Shannon Lower	IE25N010300	SH_25_335
Shannon	Ballyleague Br.	Shannon Upper	IE26S021600	SH_26_4162
SWRBD Hand-set sites				
Argideen	Ford S of Reengarrigeen	Argideen	IE20A020200	SW_20_2251
Funshion	Brackbaun Br.	Blackwater	IE18F050030	SW_18_11
SWRBD Boat sites				
Awbeg	Kilcummer Br.	Blackwater	IE18A051300	SW_18_2677
Bandon	Bridge near Desert Station	Bandon	IE20B020600	SW_20_2230_1
Blackwater	Killavullen Br.	Blackwater	IE18B021900	SW_18_2292_5
Blackwater	Nohaval Br.	Blackwater	IE18B020200	SW_18_450
Bride	Bridge N of Ballynella	Blackwater	IE18B050500	SW_18_2778
WRBD Hand-set sites				
Black	Bridge at Kilshanvy	Corrib	IE30B020100	WE_30_2928
Dunneill	Donaghintraine Br.	Dunneill	IE35D060200	WE_35_1430
Gowlan	Ford u/s of Easky River confl.	Easkey	IE35G030100	WE_35_1187
Owenbrin	Bridge u/s of Lough Mask	Corrib	IE30O010200	WE_30_1063
Owendalulleegh	Bridge SE of Killafeen	Kinvarra	IE29O011000	WE_29_150
Unshin	d/s of Riverstown Br.	Ballysadare	IE35U010200	WE_35_2178
WRBD Boat sites				
Nanny	u/s of Weir Br.	Corrib	IE30N010300	WE_30_1128

Table 2.3. Physical characteristics of river sites surveyed for WFD surveillance monitoring, 2009

River	Upstream catchment (km^2)	Wetted width (m)	Surface area (m^2)	Mean depth (m)	Max depth (m)
ERBD Hand-set sites					
Athboy	78.02	5.92	266	0.45	0.73
Blackwater	124.12	9.20	414	0.22	0.40
Dargle	113.14	16.02	593	0.27	0.72
Glencree	33.86	7.27	342	0.23	0.79
Glenealo	18.73	7.17	330	0.41	0.89
Nanny	221.68	11.73	505	0.41	0.95
ERBD Boat sites					
Boyne (Boyne Br.)	60.31	5.00	575	0.43	0.60
Liffey (Ballyward Br.)	87.70	13.00	4108	0.58	1.20
Liffey (Lucan)	1102.06	20.80	5179	0.65	1.50
NBIRBD Hand-set sites					
Big	10.58	4.28	184	0.25	0.38
White	55.13	5.99	264	0.27	0.66
NBIRBD Boat sites					
Dee	175.52	7.00	1050	0.95	1.40
NWIRBD Hand-set sites					
Clady	78.63	10.42	417	0.23	0.68
NWIRBD Boat sites					
Erne	336.37	15.00	3615	1.50	2.50
Finn	121.61	11.25	2835	1.75	3.00
SERBD Hand-set sites					
Burren	38.49	4.27	188	0.43	0.69
Greese	102.39	7.25	326	0.55	0.85
Tully Stream	44.13	4.13	178	0.50	0.93
SERBD Boat sites					
Barrow (Pass Br.)	1125.58	25.60	10906	0.96	1.80
Dinin	299.23	15.20	3390	0.52	1.40
King's	377.29	16.40	4100	1.75	2.00
Slaney	77.66	9.00	846	0.56	1.20

Table 2.3 ctn. Physical characteristics of river sites surveyed for WFD surveillance monitoring, 2009

River	Upstream catchment (km^2)	Wetted width (m)	Surface area (m^2)	Mean depth (m)	Max depth (m)
ShIRBD Hand-set sites					
Ballyfinboy	187.24	5.00	225	0.30	0.54
Bilboa	85.13	16.27	618	0.20	0.36
Broadford	34.64	5.07	203	0.53	0.86
Caher	14.91	4.73	232	0.25	0.43
Dead	61.94	5.40	243	0.36	0.70
Glendine	12.31	2.52	118	0.14	0.33
Moyree	62.56	9.62	433	0.29	0.69
Newport	68.67	12.55	502	0.32	0.80
Owvane	74.99	13.70	617	0.24	0.67
Owveg	18.53	5.80	249	0.17	0.63
Tyshe	8.52	2.61	196	0.37	0.65
ShIRBD Boat sites					
Creegh	76.00	7.31	1162	0.33	0.71
Feorish	89.07	7.25	573	2.50	2.50
Fergus	138.70	15.00	4425	2.50	2.50
Nenagh	82.44	7.20	994	0.52	0.90
Shannon	2773.77	87.50	34738	>2.00	0.00
SWRBD Hand-set sites					
Argideen	1698.67	12.16	547	0.49	0.82
Funshion	16.19	9.00	405	0.22	0.35
SWRBD Boat sites					
Awbeg	350.44	15.80	3792	0.46	0.80
Bandon	337.05	21.40	5543	0.57	0.80
Blackwater (Killavullen)	1256.72	40.00	21840	1.10	2.00
Blackwater (Nohaval)	89.00	11.40	2029	0.44	1.00
Bride	226.78	16.80	4754	0.46	0.70
WRBD Hand-set sites					
Black	3.12	6.43	270	0.23	0.41
Dunneill	24.35	7.75	504	0.25	0.57
Gowlan	17.00	6.63	550	0.39	0.81
Owenbrin	23.82	11.53	519	0.21	0.54
Owendalulleegh	90.48	10.58	476	0.26	0.53
Unshin	76.24	8.23	329	0.40	0.61
WRBD Boat sites					
Nanny	36.74	6.33	727	0.73	1.05

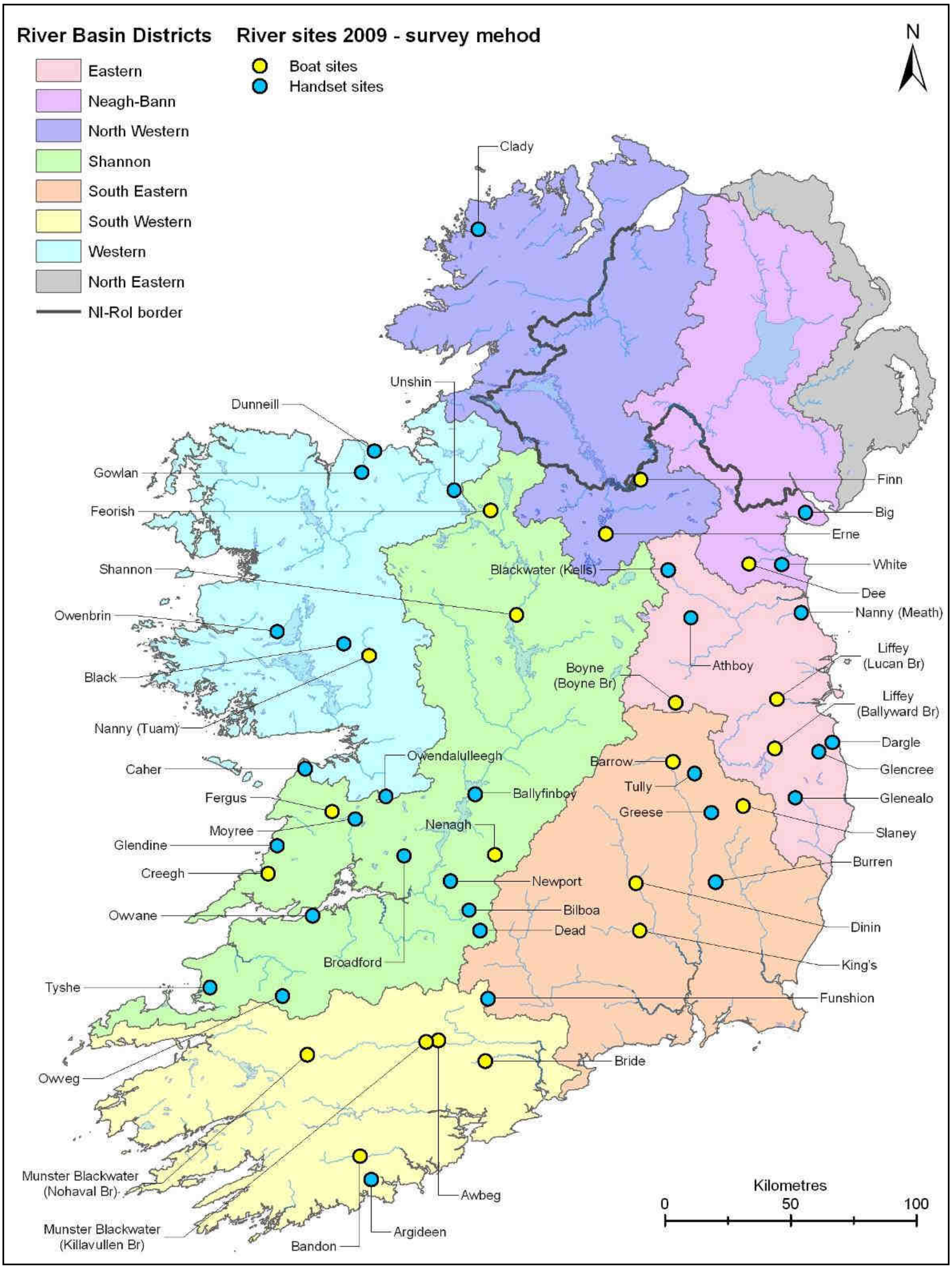

Fig. 2.2. Location map indicating the 54 river sites surveyed as part of the WFD fish surveillance monitoring programme, June to October 2009

2.3 Transitional waters

Twenty-three transitional water bodies, ranging in size from 0.08km^2 (Bridge Lough, Knockakilleen in Co. Galway) to 59.36km^2 (Swilly estuary, Co. Donegal), were surveyed between September and October 2009. These sites were distributed throughout six RBDs (Table 2.4 and Fig. 2.3).

One site was surveyed in the ERBD with an area of 3.16km^2 (Boyne Estuary, Co. Louth). Two were surveyed in the SWRBD, ranging in size from 0.35km^2 (Upper Bandon Estuary, Co. Cork) to 6.79km^2 (Lower Bandon Estuary, Co. Cork). Two were surveyed in the NBIRBD, ranging in size from 1.88km^2 (Castletown Estuary, Co. Louth) to 33.35km^2 (Inner Dundalk Bay, Co. Louth). Six were surveyed in the SERBD, ranging in size from 0.37km^2 (North Slob Channels, Co. Wexford) to 18.35km^2 (Lower Slaney Estuary, Co. Wexford). Six were surveyed in the WRBD, ranging in size from 0.08km^2 (Bridge Lough, Knockakilleen) to 10.75km^2 (Camus Bay, Co. Galway). Six sites were surveyed in the NWRBD, ranging from 0.70km^2 (Durnesh Lough, Co. Donegal) to 59.36km^2 (Swilly Estuary, Co. Donegal).

Table 2.4. List of Transitional water bodies surveyed for WFD surveillance monitoring between September and October 2009 (FT=freshwater tidal, TW=transitional and L=lagoon)

Transitional Water body	MS Code	Easting	Northing	Type	Area (km^2)
SWRBD					
Upper Bandon Estuary	SW_080_0300	155716	55871	FT	0.35
Lower Bandon Estuary	SW_080_0100	158029	51623	TW	6.79
ERBD					
Boyne Estuary	EA_010_0100	313778	276399	TW	3.16
NBIRBD					
Castletown Estuary	NB_040_0200	307493	308320	TW	1.88
Inner Dundalk Bay	NB_040_0100	311060	304506	TW	33.35
SERBD					
Bridgetown Estuary	SE_080_0100	291841	107934	TW	2.03
Tacumshin Lake	SE_070_0100	305135	106528	L	3.11
Lady's Island Lake	SE_060_0100	309650	106515	L	2.96
North Slob Channels	SE_040_0100	307472	124835	L	0.37
Upper Slaney Estuary	SE_040_0300	297785	135653	FT	0.80
Lower Slaney Estuary	SE_040_0200	303790	124978	TW	18.35
WRBD					
Lough Athola	WE_260_0100	62586	248410	L	0.11
Bridge Lough	WE_160_0200	133901	213038	L	0.08
Camus Bay	WE_200_0200	94485	233785	TW	10.75
Kinvarra Bay	WE_160_0100	136233	212338	TW	5.72
Loch an Aibhinn	WE_200_0700	94702	231553	L	0.54
Lough Murree	WE_120_0100	125455	211937	L	0.13
NWIRBD					
Inner Donegal Bay	NW_050_0100	191394	375542	TW	8.12
Durnesh Lough	NW_040_0100	311060	304506	L	0.70
Erne Estuary	NW_030_0100	187760	369317	TW	2.58
Gweebarra Estuary	NW_120_0100	185343	361866	TW	8.26
Inch Lough	NW_220_0300	183113	402412	L	1.62
Swilly Estuary	NW_220_0100	297785	135653	TW	59.36

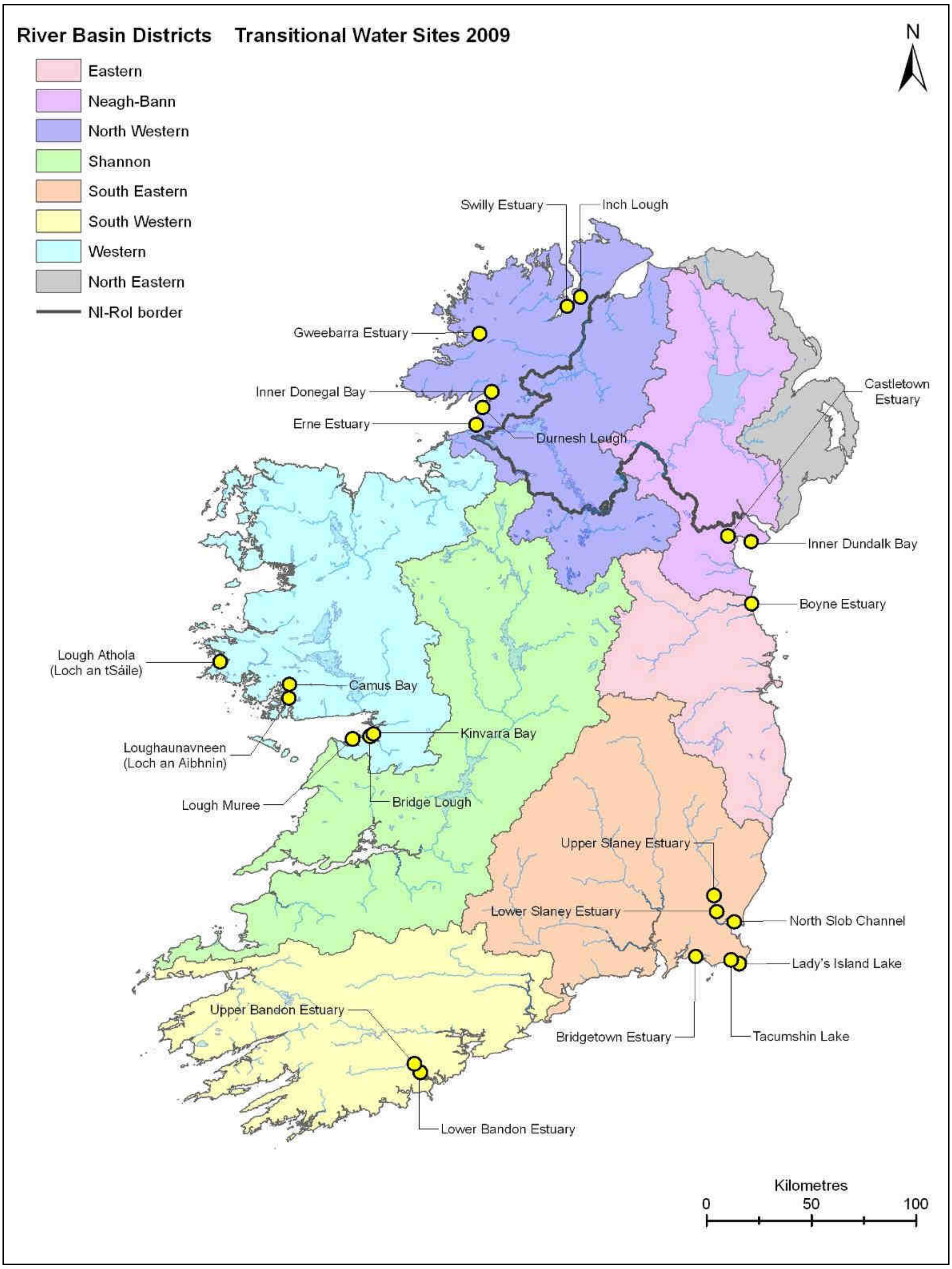

Fig. 2.3. Location map indicating the 23 transitional water bodies surveyed as part of the WFD fish surveillance monitoring programme, September to October 2009

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

Twenty-three 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 halved 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 is 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 is then conducted within each depth stratum (CEN, 2005b). Surface floating survey gill nets (Plate 3.1), fyke nets (one unit comprised of 3 fyke nets; leader size 8m x 0.5m, Plate 3.2) 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 the 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 and pike. 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. Scales were used for age analysis of other selected fish species. Stomach contents and sex were determined for any fish retained.

3.1.3 Water chemistry

One water sample was collected from the middle of each lake in a plastic two litre bottle and transported to the CFB laboratory for analysis of a suite of variables, including total phosphate, alkalinity and chlorophyll. Conductivity, temperature, dissolved oxygen and pH were measured on site using a multiprobe. A Secchi disc was used to measure the clarity of the water in each lake.

Plate 3.1. Setting a monofilament surface floating multi-mesh CEN standard survey gill net on Lough Allen, Co. Leitrim (2006)

Plate 3.2. 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 water body sites. A standard methodology was drawn up for the WFD surveillance monitoring programme (CFB, 2008a), in compliance with the European CEN standard for fish stock assessment in wadeable rivers (CEN, 2003). The complete survey includes fish sampling, hydrochemistry sampling and a physical habitat survey. A macrophyte survey was also carried out at selected wadeable sites. Surveys were carried out between July and early October (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 fishings were carried out 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 3.3 left). 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 3.3 right). A representative sample of all habitats was sampled (i.e. riffle, glide, pool).

Plate 3.3. Electric fishing with bank-based generators (left) in the River Gourna (2008) and boat-based generators on the Nenagh River (right)

Fish from each pass/fishing 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

3.4). All fish were held in a large bin of 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 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 fishing pass only.

Plate 3.4. Processing fish for length, weight and scale samples

3.2.2 Environmental and abiotic variables

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. Riffles were classified as areas of fast water with a broken-surface appearance, pools were classified as areas of slow deep water with a smooth surface appearance and glides were intermediate in character. A summary of environmental and abiotic variables, showing the range amongst all river sites surveyed, is shown in Table 3.1.

Table 3.1. Environmental and abiotic variables for all river sites

Environmental / abiotic variable	Min	Max	Mean	Footnote
River reach sampled				
Length fished (m)	37	546	129	1
Mean depth (m)	0.14	2.50	0.62	2
Max depth (m)	0.33	3.0	1.04	3
Mean wetted width (m)	2.52	87.5	12.51	4
Surface area (m^2)	118	34738	2631	5
Shade due to tree cover (%)	0	4	-	6
Instream cover (%)	0	80	15	7
Land use	n/a	n/a	-	8
Bank slippage	0	1	-	9
Bank erosion	0	1	-	9
Fencing (RHS & LHS)	0	1	-	9
Trampling (RHS & LHS)	0	1	-	9
Velocity status	1	3	-	10
Velocity rating	1	7	-	11
Flow type (%)				
Riffle	0	100	22.72	7
Glide	0	100	54.07	7
Pool	0	75	23.21	7
Substrate type (%)				
Bedrock	0	20	0.81	7
Boulder	0	50	7.94	7
Cobble	0	90	48.46	7
Gravel	0	75	20.16	7
Sand	0	80	11.39	7
Mud/silt	0	100	11.25	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. Land use in the immediate area of the site estimated visually at time of sampling
9. Bank slippage, bank erosion, fencing estimated visually at time of sampling (presence or absence recorded as 1 or 0)
10. Water level, estimated visually at time of sampling-3 grades (1-low, 2-normal & 3-flood)
11. 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 open sea. As such, they provide a challenging habitat to survey as nothing remains stable for very long. 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 the Research and Development division of the Central Fisheries Board 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 was conducted at each site using a four-person team; two staff on shore and two in a boat. Sampling stations were 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, through presence of very soft sediments or obstructions on the estuary bed, were also considered. Some sites were available at particular stages of the tide only.

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 3.5), with one end or guide rope held on shore while the boat followed an arc until the full net was 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 3.6).

Plate 3.5. Beach seining: deploying the net from a boat

Plate 3.6. Beach seining: hauling the net towards shore by hand

3.3.1.2 Fyke netting

“Dutch” type fyke nets, identical to those used for lake surveys (one unit comprised of 3 fyke nets; leader size 8m x 0.5m, Plate 3.7), are the standard fyke nets used to sample fish in transitional waters. Each fyke net unit was weighted by two anchors to prevent drifting and a marker buoy was attached to each end.

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

Plate 3.7. Fyke net being hauled aboard a rigid inflatable boat (RIB)

3.3.1.3 Beam trawl

A beam trawl was used successfully on a number of transitional water sites. This technique enables sampling of littoral and open water habitats where the bed type is suitable. The beam trawl used in the 2009 survey was developed by the Northern Ireland Environmental Agency (NIEA) and is used in transitional water sampling in Northern Ireland. The trawl measures 1.5m x 0.5m in diameter, with a 10mm mesh bag, decreasing to 5mm mesh in the cod end (Plate 3.8). A 1.5m metal beam ensured the bag stayed open while towing, with small floats on the top line and 3m of light chain on the bottom line. A 1m bridal was attached to a 20m tow rope and the net was towed by a 3.8m RIB.

Trawls were carried out 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 3.8. 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 millimeter. Any fish species that could not be identified on site were preserved in ethanol or frozen and taken back to the CFB 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 Aging of fish

A subsample of the dominant fish species were aged (five fish from each 1cm class); fish scales were aged using a microfiche reader. Perch opercular bones, prepared by boiling, cleaning and drying, were aged using a binocular microscope/digital camera system and char otoliths were immersed in alcohol and aged using a binocular microscope. Eel otoliths were prepared for aging by the method of 'cutting and burning' and were subsequently aged using a binocular microscope/digital camera system (Plates 3.9 to 3.11). Back calculated lengths at age were determined in the laboratory.

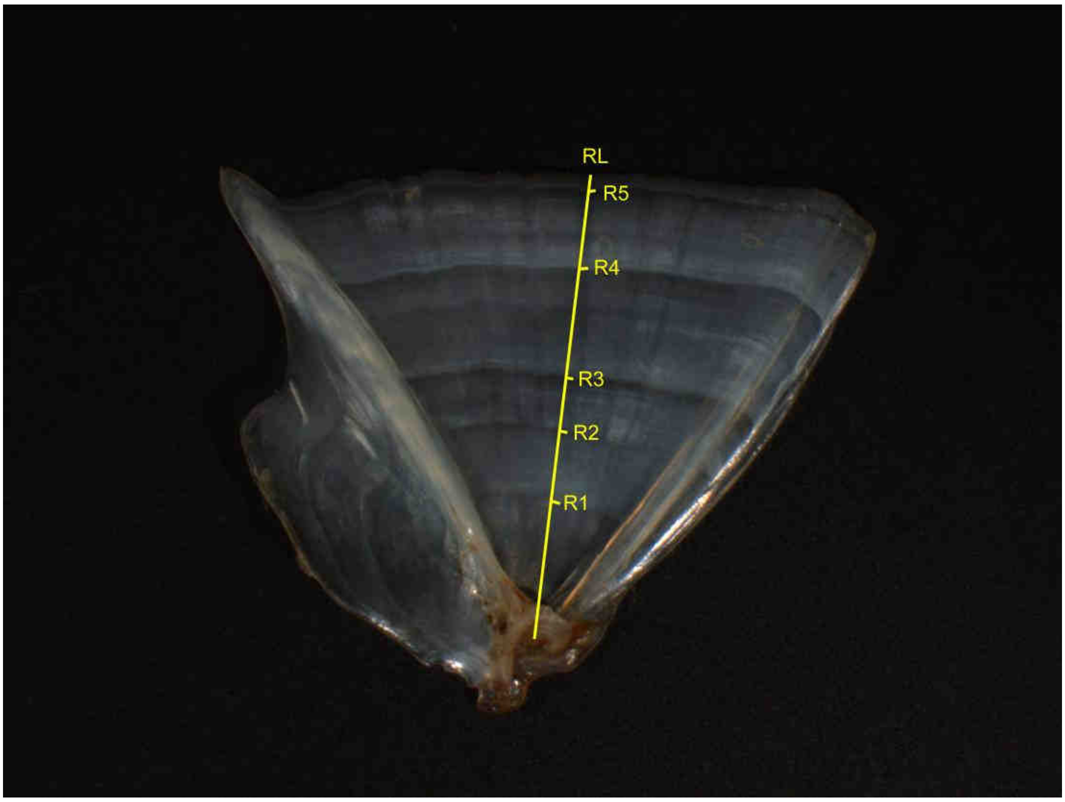

Plate 3.9. Image of an opercular bone from a perch (5+) from the River Suck at Cloondacarra Bridge

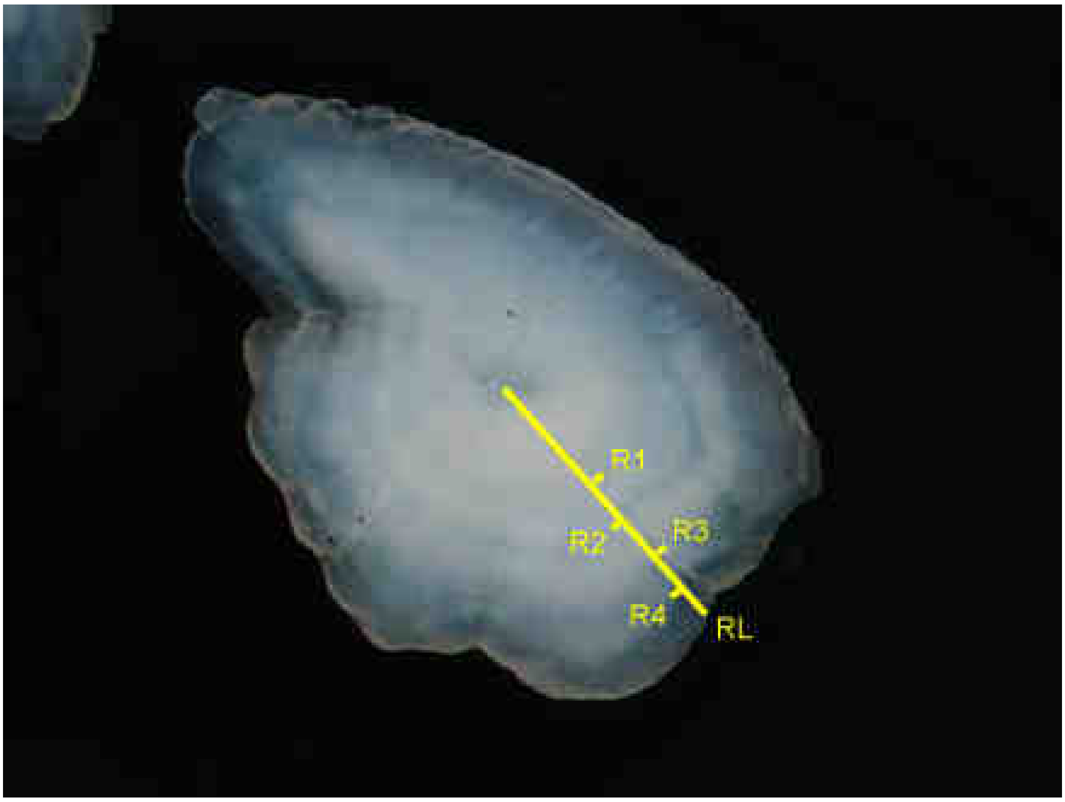

Plate 3.10. Image of an otolith from a char (4+) from Kindrum Lough, Co. Donegal

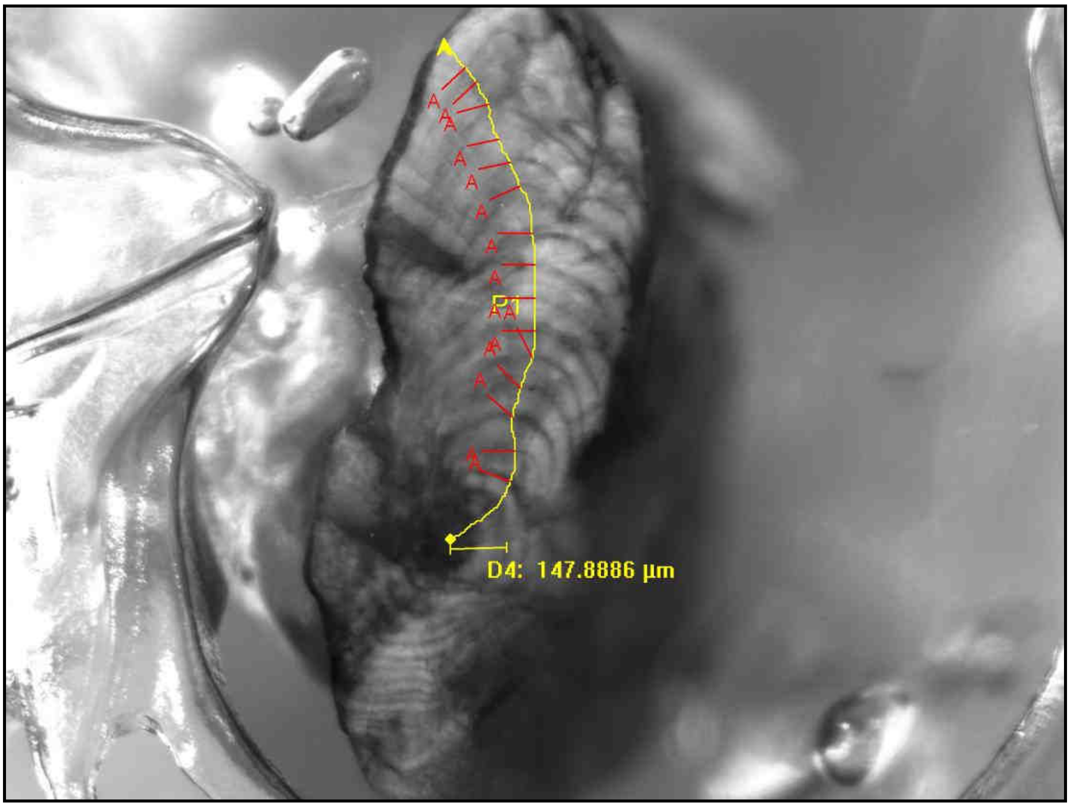

Plate 3.11. Image of an otolith from a female eel (15+) from Lough Cullin

3.5 Quality assurance

CEN (2005a) recommends that all activities in the fish sampling method (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 operators, particularly in relation to hybrids of coarse fish. Samples of each fish species (from the three water body types) were retained when the operative was in any doubt in relation to the identity of the species, e.g. rudd and/or roach hybrids. Staff working in transitional waters attended a training course on identification of fish in estuaries, hosted by the Environment Agency of England and Wales.

There is also a need for quality control when aging fish; therefore every tenth scale or bone from each species was checked in the laboratory by a second biologist experienced in age analysis techniques. New equipment and imaging software for aging fish was introduced in 2008 to support this exercise.

Further quality control measures will be implemented during 2010 in relation to standardising data analyses, database structure and reporting.

All classification tools for fish will continue to be developed during 2010 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 produced by 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.

3.7 Hydroacoustic technology; new survey method development in rivers and lakes

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. Very high frequency systems have also been developed, with frequencies in the thousands of KHz. These are typically used in fixed locations, such as fish passes, where they produce an almost video-like display of passing fish.

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 3.12 below shows a typical echo sounder setup for use in freshwater hydroacoustic fish surveys.

Plate 3.12. 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, that 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. 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). Furthermore, the spatial distribution and size distribution of species of interest can also be assessed.

Horizontal hydroacoustic surveys involve orientating the transducer so that the acoustic beam is directed just below the surface. In this way, fish inhabiting the shallow areas of lakes as well as deep rivers, where vertical hydroacoustics are ineffective, can be targeted. However; horizontal hydroacoustic surveys are greatly influenced by the time of day during which they are conducted. During the daytime, for example, most fish species are less active and tend to inhabit areas in rivers close to the bank or the riverbed where they cannot be detected reliably. It is the case, therefore, that horizontal hydroacoustic surveys are much more effective when conducted during the night-time when fish are more active and spread out in the water column. This situation is not so important for vertical hydroacoustic surveys of fish inhabiting the deep waters of lakes.

Comparing day-time versus night-time hydroacoustic surveys in lakes can also provide valuable information on fish behaviour. It is often the case that during the day-time, pelagic fish will be associated with mid-water plankton layers, rising in the water column at night-time as the zooplankton migrate towards the surface.

3.7.3 Hydroacoustics and the Water Framework Directive

The Water Framework Directive specifies that information must be collected on fish species composition, abundance and age structure. Robust sampling methods for fish in lakes and rivers have been developed based on CEN standards for fish sampling (CEN 2003, CEN 2005a, CEN 2005b). These methods involve a multi-method netting approach for fish in lakes and electric-fishing in rivers. Using these methods, all three of the WFD parameters can be collected.

As previously stated, hydroacoustics can provide high resolution information on fish abundance and spatial distribution; however, a certain amount of targeted ‘ground-truth’ netting or electric-fishing is still required to identify species and to obtain scale samples for aging. Challenges also exist in the development of a standardised approach for hydroacoustic surveys to both compare lakes with each other and to compare individual lakes over time. A European CEN standard for sampling fish with hydroacoustic technology is currently under development. Hydroacoustic surveys are much more weather and habitat dependent than netting surveys, therefore planning a standardised monitoring schedule using hydroacoustics as a main monitoring tool would be extremely optimistic. Furthermore, most of the lakes surveyed for the WFD are relatively shallow, meaning vertical hydroacoustics would be ineffective as a sampling method.

Nevertheless, the further development of both hydroacoustic technology and sampling methodology is certain to see hydroacoustics playing an ever more important role in WFD monitoring in the future.

3.7.4 Examples of hydroacoustic output

During 2009, staff training and trial surveys were conducted on a number of lakes with newly acquired hydroacoustic equipment. A dual frequency system was acquired with two horizontal and two vertical transducers operating at frequencies of 120 and 200KHz. A multiplexer enables all four transducers to be used simultaneously by alternating the pings between each transducer operating on the same frequency. Although it is difficult to use the data from these trials for detailed fish abundance analyses, examples of echograms from selected surveys are shown below to illustrate the effective use of hydroacoustics in fish stock assessments.

Figures 3.1 and 3.2 show echograms from the same location in Lough Mask (8^{th} – 18^{th} June 2009) during vertical data recording with the hydroacoustic operating software (Fig. 3.1) and during post-processing with the Sonar5-Pro (Balk and Lindem, 2004) post-processing software (Fig. 3.2). The maximum water depth is approximately 55m, with a distinct plankton band present from 30 – 35m. Individual fish targets (typical of Arctic char in this case) are seen in deep water below this plankton band. These targets can be readily counted during day-time or night-time surveys. Fish targets can also be seen above the plankton band. Many fish associated with the plankton band cannot be enumerated during day-time surveys as the ‘noise level’ from the plankton band masks any distinct returning echoes. This plankton band would typically rise during the night-time and many more individual fish targets would be seen. Reliable estimates of pelagic fish are therefore best attained from night-time surveys. Air bubbles (seen as columns or stacks on the right of the echogram) could easily be mistaken for fish targets to the untrained eye and included in fish abundance estimates. Clearly this would give an overestimation of fish population size within this area, therefore care is needed in the interpretation of the recorded acoustic data and the removal of unwanted detections is necessary before completing any abundance analysis.

Figures 3.3 and 3.4 show echograms from the River Barrow at Graiguenamanagh (31^{st} May 2010) recorded during a horizontal hydroacoustic survey conducted at both day-time and night-time on the same stretch of river. During day-time (Fig. 3.3) there are very few fish targets seen in the river channel, with a dense band of vegetation (and associated fish) on or near the river bed and shore. Fish in this band cannot be enumerated due to the ‘noise’ from the surrounding vegetation. During the night-time (Fig. 3.4) fish become more active and move out from the cover of the vegetation into the main river channel and can be seen as individual tracks. In this situation, abundance and spatial distribution estimates can be conducted more readily.

3.7.5 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.

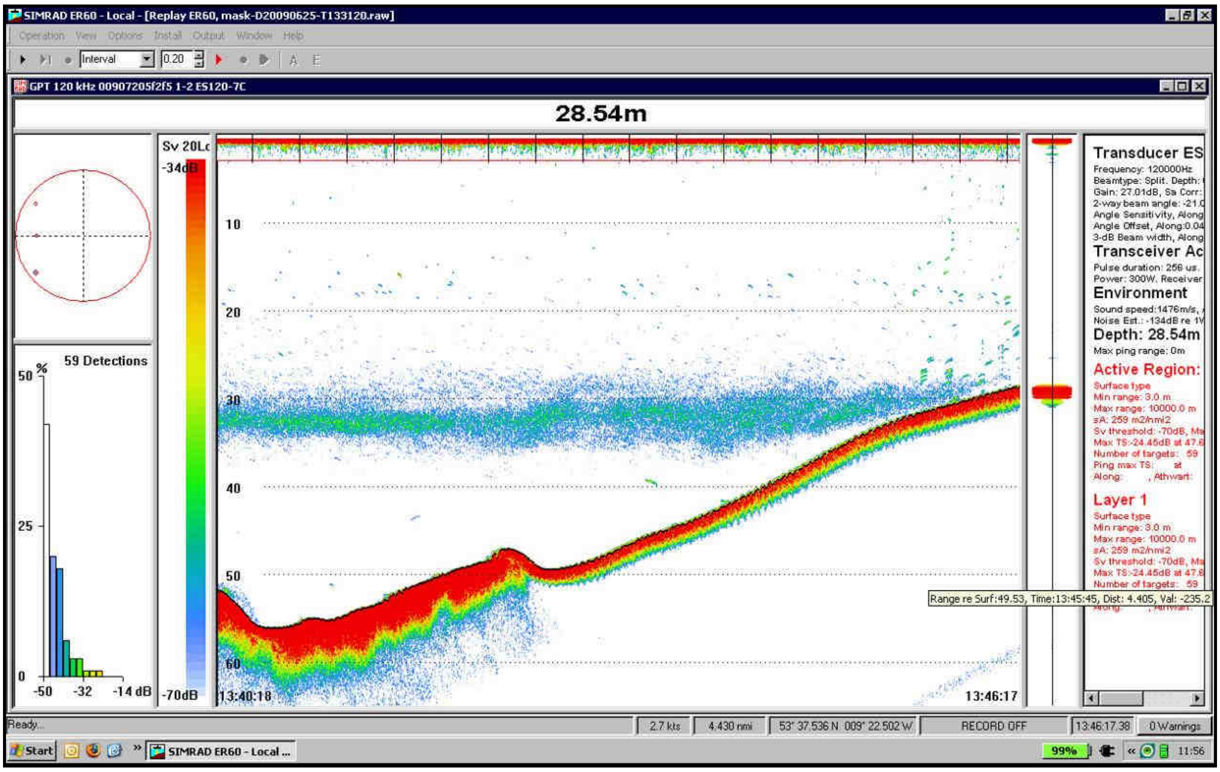

Fig. 3.1. Example of an echogram from Lough Mask during data recording with the hydroacoustic operating software

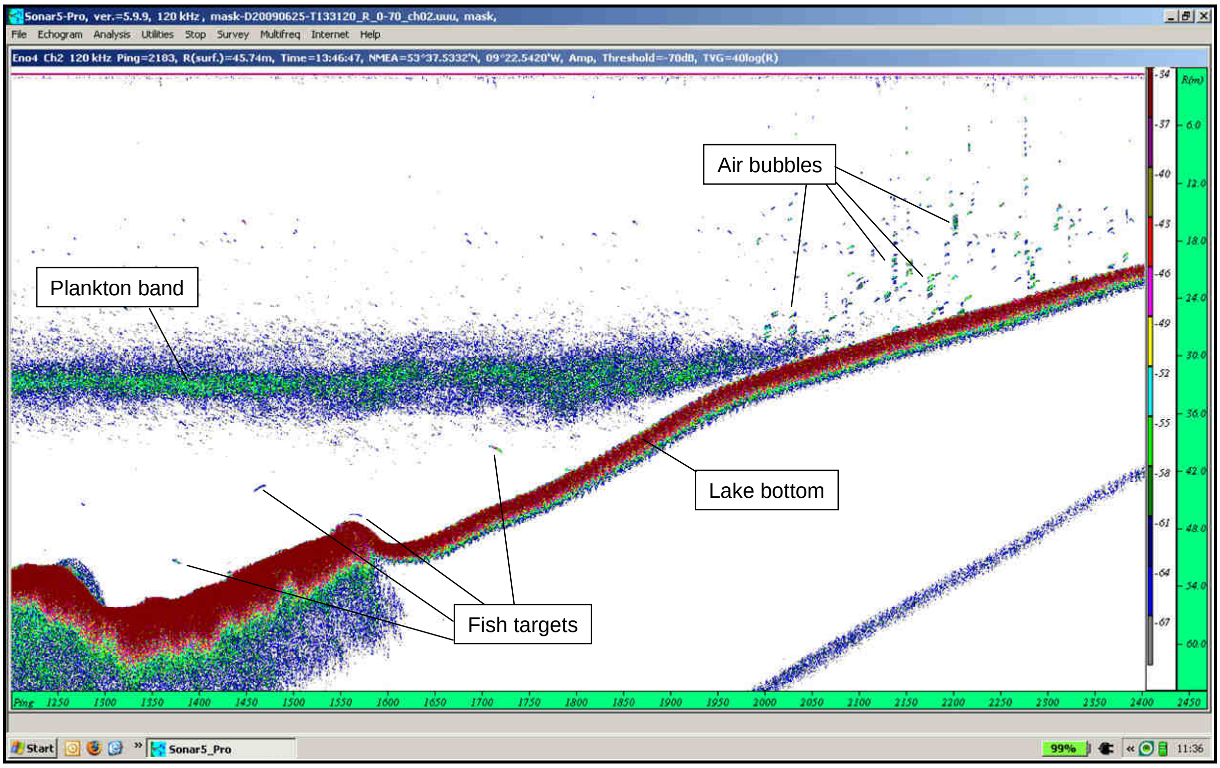

Fig. 3.2. Example of an echogram from Lough Mask during post-processing

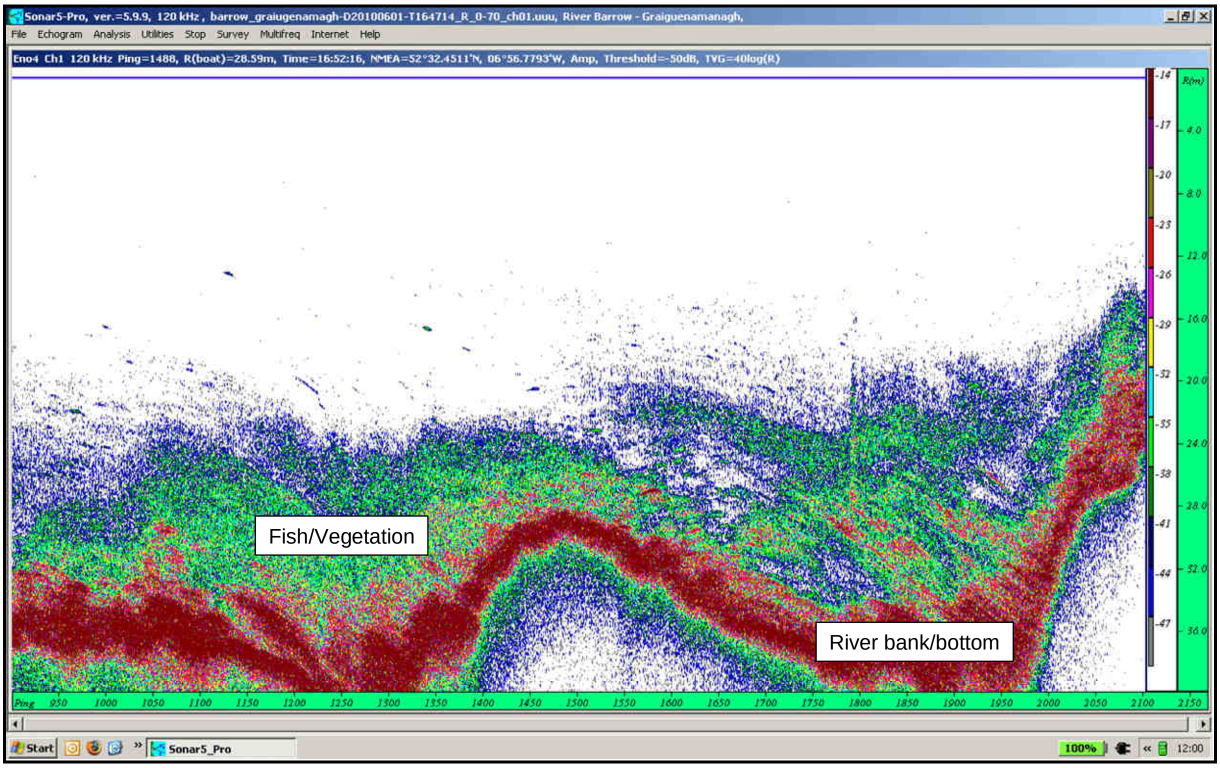

Fig. 3.3. Example of an echogram from the River Barrow at Graiguenamanagh recorded during day-time

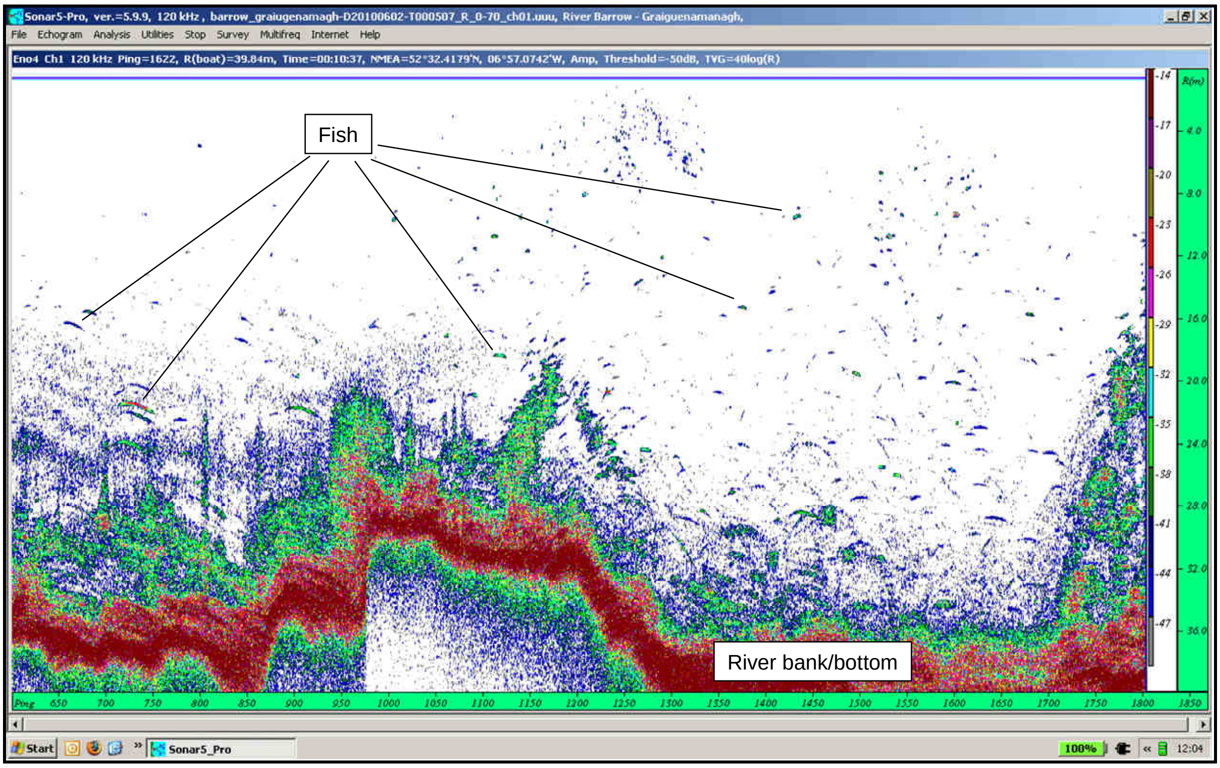

Fig. 3.4. Example of an echogram from the River Barrow at Graiguenamanagh recorded during night-time

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 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 in the 23 lakes surveyed during 2009 is shown in Table 4.1. The percentage of lakes in which each fish species occurred is shown in Table 4.1 and Figure 4.1.

Table 4.1. List of fish species recorded in the 23 lakes surveyed during 2009

	Scientific name	Common name	Number of lakes	% lakes
	NATIVE SPECIES			
1	*Salmo salar* Linnaeus, 1758	Juvenile salmon	1	4.3
2	*Salmo trutta* Linnaeus, 1758	Brown trout	16	69.6
3	*Salmo trutta* Linnaeus, 1758	Sea trout*	2	8.7
4	*Salvelinus alpinus (Linnaeus, 1758)*	Char	4	17.3
5	*Gasterosteus aculeatus* (L.)	Three-spined stickleback	6	26.1
6	*Anguilla anguilla* (L.)	Eel	23	100
	NON NATIVE SPECIES (influencing ecology)			
7	*Esox lucius* (L.)	Pike	14	60.9
8	*Rutilus rutilus* (L.)	Roach	7	30.4
9	*Perca fluviatilis* (L.)	Perch	13	56.5
10	*Abramis brama* (Linnaeus, 1758)	Bream	5	21.7
11	*Phoxinus phoxinus* (L.)	Minnow	1	4.3
12	*Oncorhynchus mykiss* (Walbaum, 1792)	Rainbow trout	1	4.3
	NON NATIVE SPECIES (generally not influencing ecology)			
13	*Tinca tinca* (Linnaeus, 1758)	Tench	3	13
14	*Gobio gobio* (L.)	Gudgeon	1	4.3
15	*Scardinius erythropthalmus (Linnaeus, 1758)*	Rudd	7	30.4
	Hybrids			
	Roach x bream hybrid		4	17.4

*Sea trout are included as a separate “variety” of trout

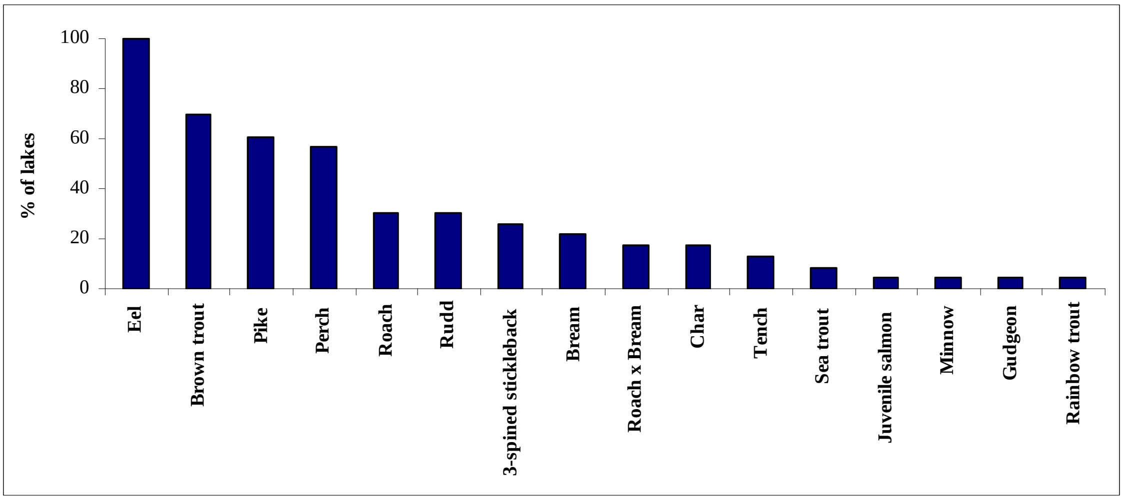

Fig. 4.1. Fish species present at lakes (% of lakes) surveyed for WFD SM monitoring 2009

Overall, a total of fifteen (sea trout are included as a separate "variety" of trout) species of fish and one type of hybrid were recorded from a total of 23 lakes surveyed during 2009 (Table 4.1). Eel was the most common fish species, occurring in 100% of lakes surveyed, followed by brown trout (69.6%), pike (60.9%) and perch (56.5%) (Fig. 4.1).

Fish species richness (excluding hybrids) ranged from two species at three lakes (Lough Dan, Lough Nasnahida and Lough Tay) to a maximum of eight species at one lake (Lough Arrow) (Table 4.2, Fig. 4.2). The highest number of native species (six species) was recorded in Doo Lough. Native species (Group 1) were present in all lakes, Group 2 species in 16 lakes and Group 3 species in 10 lakes (Table 4.2).

Table 4.2. Species richness at each lake surveyed between June and October 2009

Lake	Species richness	No. native species (Group 1)	No. non-native species (Group 2)	No. non-native species (Group 3)
Dan	2	2	0	0
Nasnahida	2	2	0	0
Tay	2	2	0	0
Dungloe	3	3	0	0
Gur	3	1	1	1
Anure	3	2	1	0
Caum	3	2	1	0
Bunny	4	1	2	1
Dromore	4	1	2	1
Inchicronan	4	1	2	1
Alewnaghta	4	1	3	0
Kindrum	4	4	0	0
Sessiagh	4	4	0	0
Cullaun	5	2	2	1
Carra	5	3	2	0
White	5	1	4	0
Cullin	6	2	3	1
Doo	6	6	0	0
Muckno	6	1	4	1
Muckanagh	7	3	2	2
Derg	7	2	4	1
Mask	7	3	4	0
Arrow	8	3	4	1

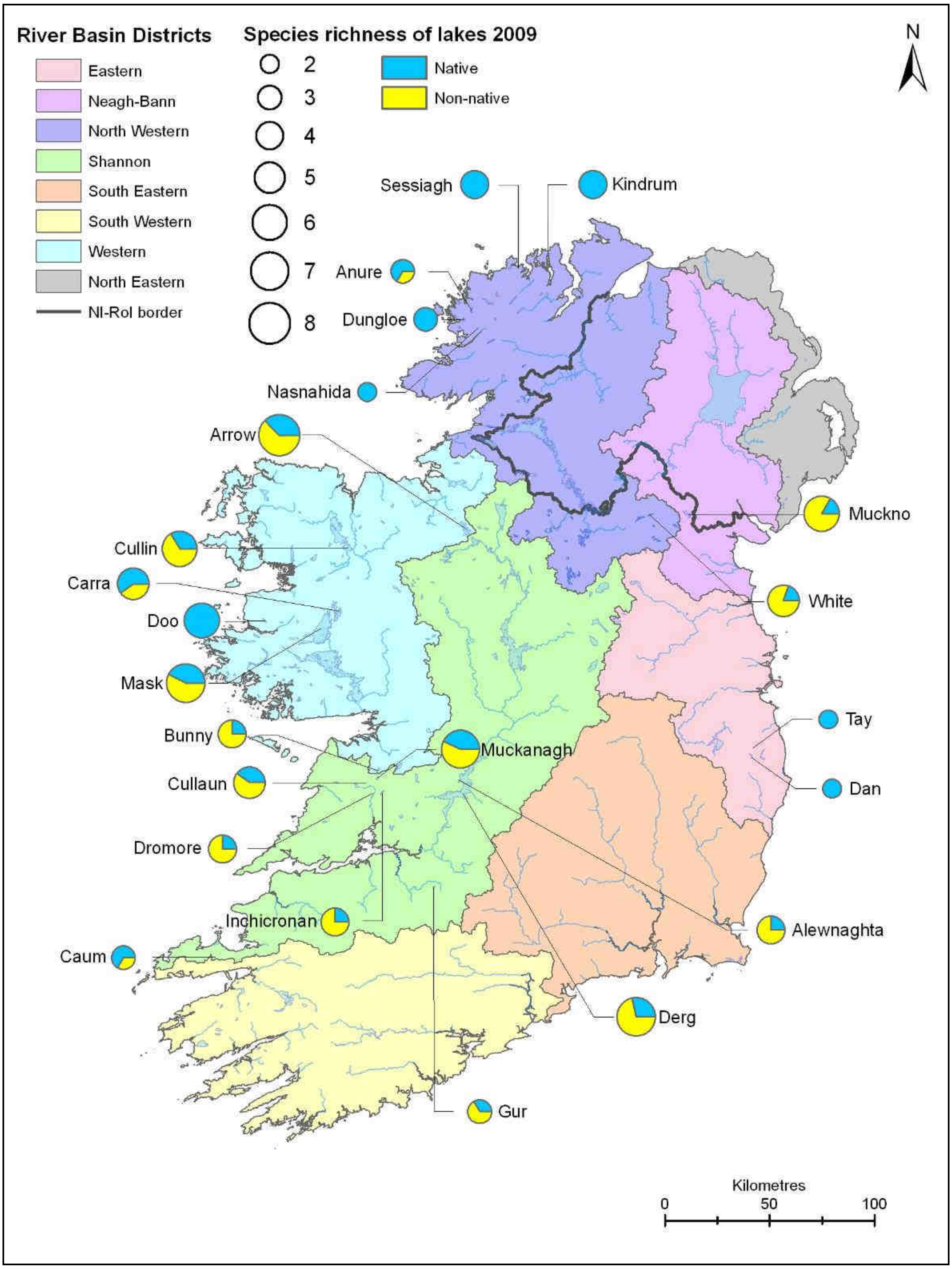

Fig 4.2 Fish species richness in 23 lakes surveyed for WFD fish monitoring 2009

4.1.2 Fish species distribution

Figures 4.3 to 4.15 show the distribution of each fish species among all lakes surveyed in 2009. 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 is also given in Appendix 2. Eels were widely distributed, being present in all lakes surveyed (Fig. 4.3). In general, salmonids dominated lakes in the north-west, west, south-west and eastern areas, being absent in many lakes in the ShIRBD and in the southern end of the NWIRBD and NBIRBD (Figs. 4.4 to 4.7). Sea trout were only present in one lake in the north-west (Dungloe Lough) and one lake in the west (Doo Lough) (Fig. 4.5). Juvenile salmon were only recorded in one lake (Doo Lough) (Fig. 4.6). Char were recorded in four lakes in the NWIRBD and WRBD – Kindrum Lough, Lough Sessiagh, Doo Lough and Lough Mask (Fig. 4.7). Three-spined stickleback were also restricted to the north and north-west of the country, being present in six lakes (Fig. 4.8).

The native Irish lake fish fauna has been augmented by the introduction of a large number of non-native species which were stocked 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). Pike, followed by perch were the most widely distributed non-native species recorded during the 2009 surveillance monitoring programme, with pike (Fig. 4.9) being present in 14 and perch (Fig. 4.10) being present in 13 out of the 23 lakes surveyed. Roach were captured in seven lakes (one each in the southern end of the NWIRBD and ShIRBD, three in the WRBD and two in the Co. Clare/Co. Galway region of the ShIRBD) (Fig. 4.11). Rudd were present in seven lakes (six lakes within the Co. Clare/Co. Limerick area of the ShIRBD and one in the WRBD in Co. Sligo) (Fig. 4.12). Bream were recorded in five lakes, roach x bream hybrids were recorded in four lakes and tench were captured in three lakes (Figs. 4.13 to 4.15).

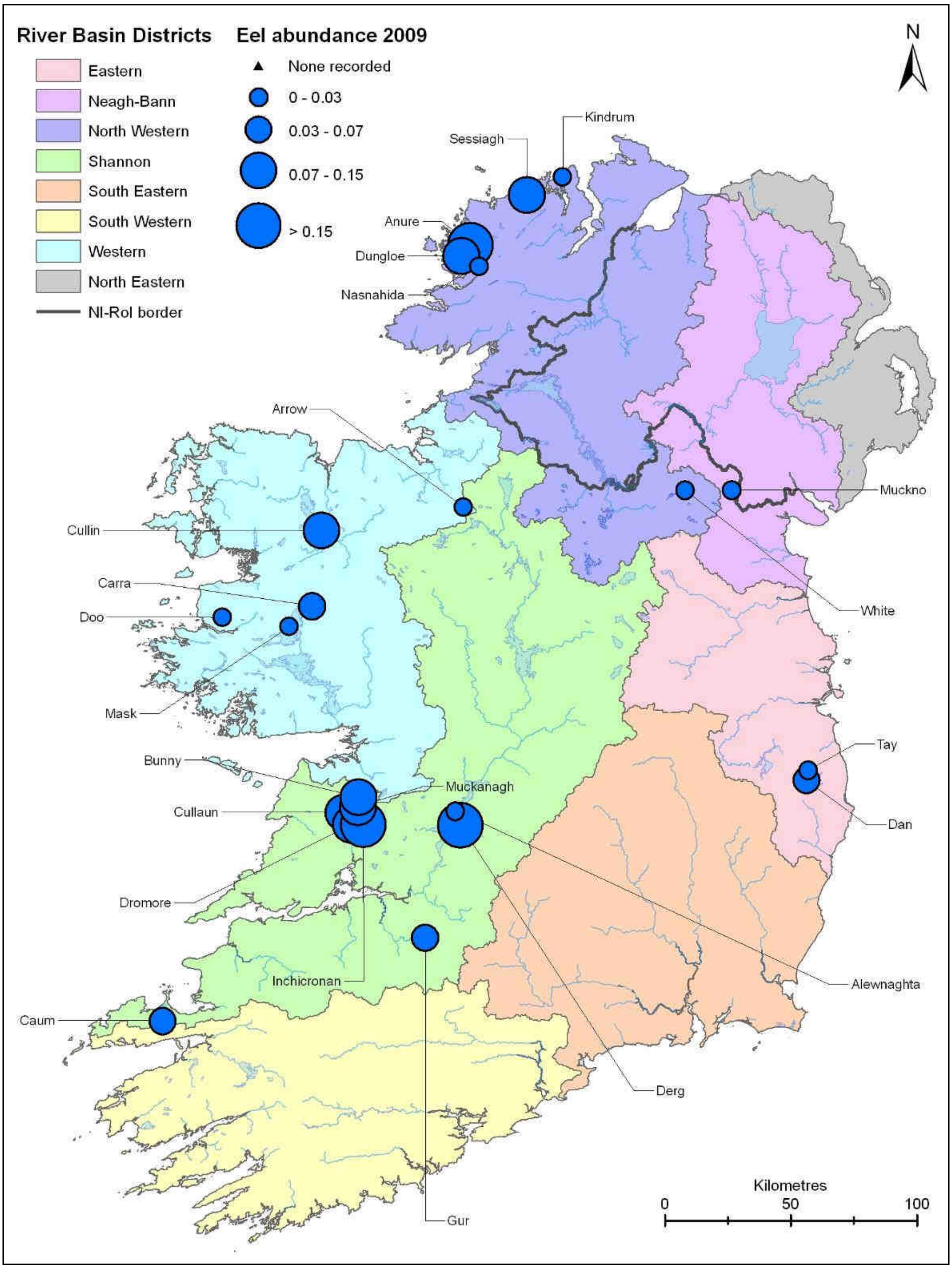

Fig. 4.3. Eel distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

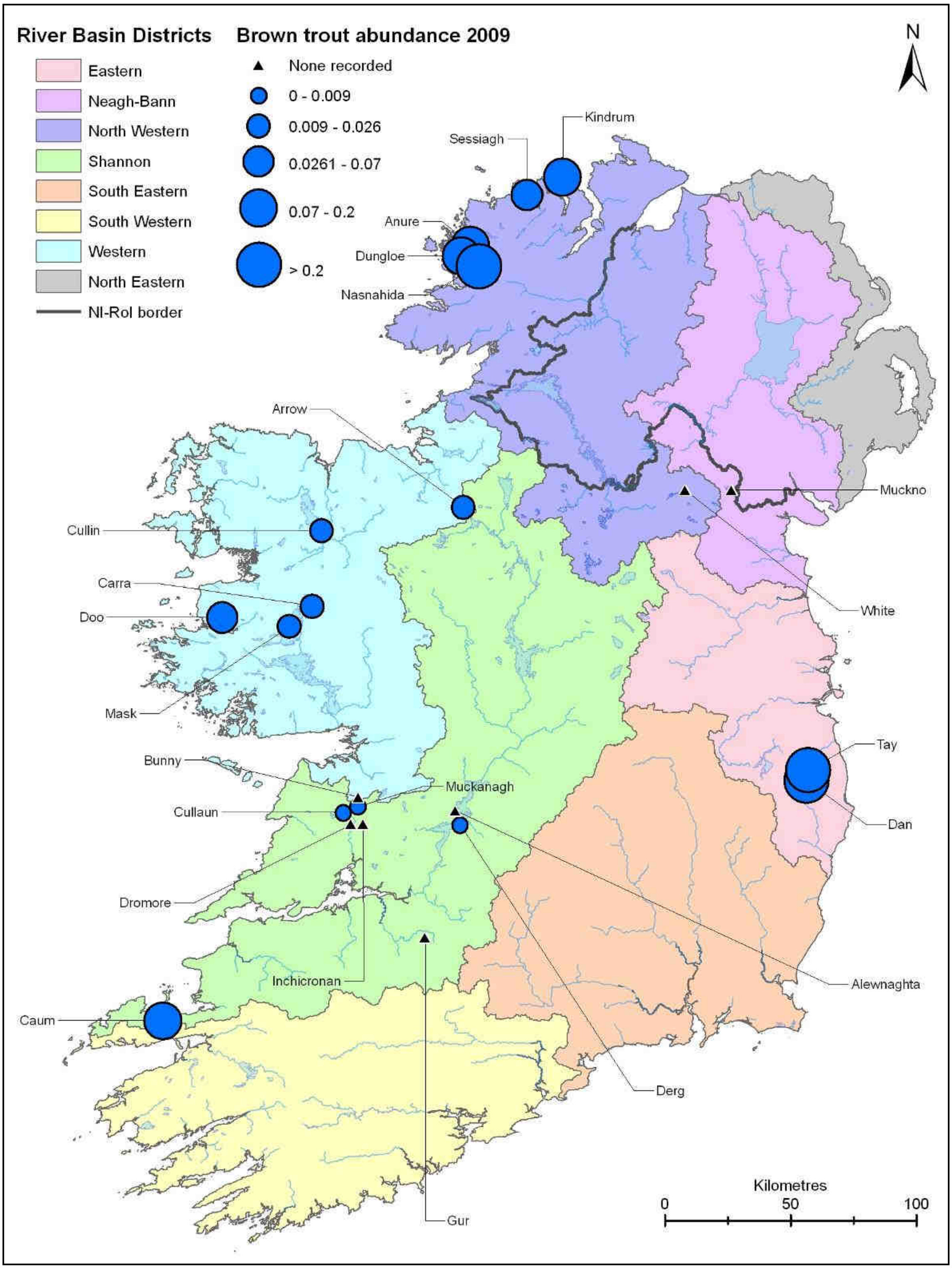

Fig. 4.4. Brown trout distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

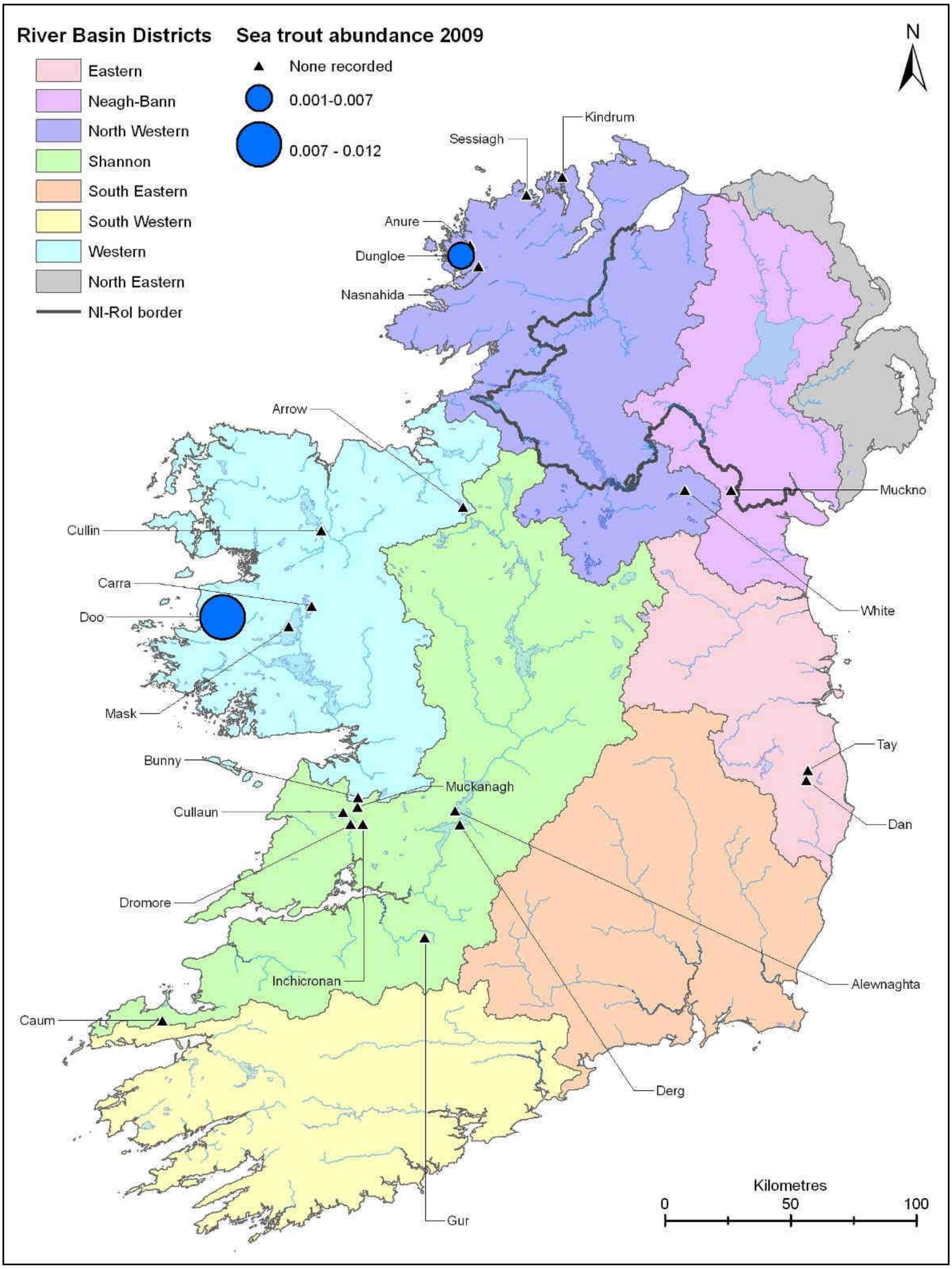

Fig. 4.5. Sea trout distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

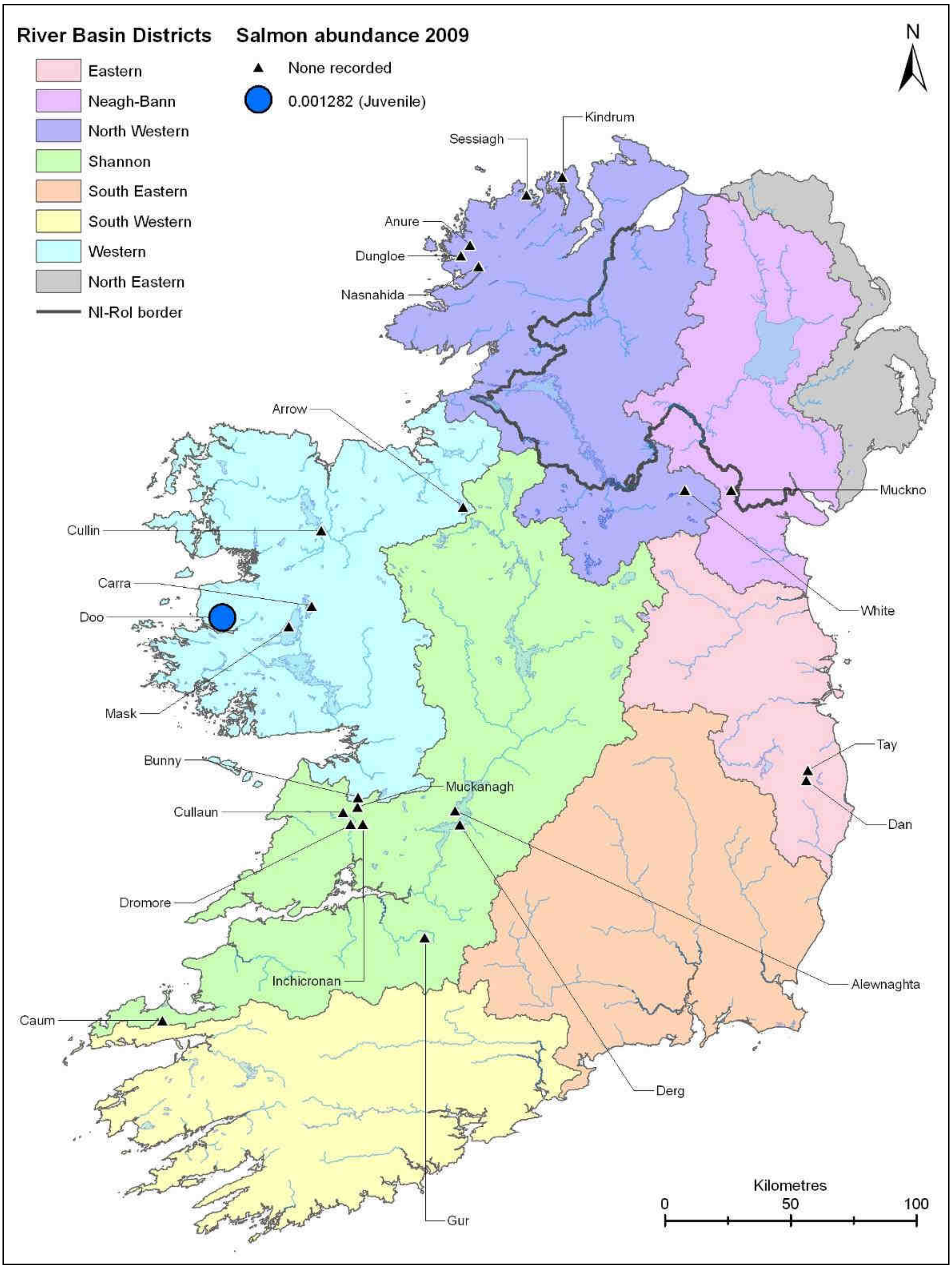

Fig. 4.6. Salmon distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

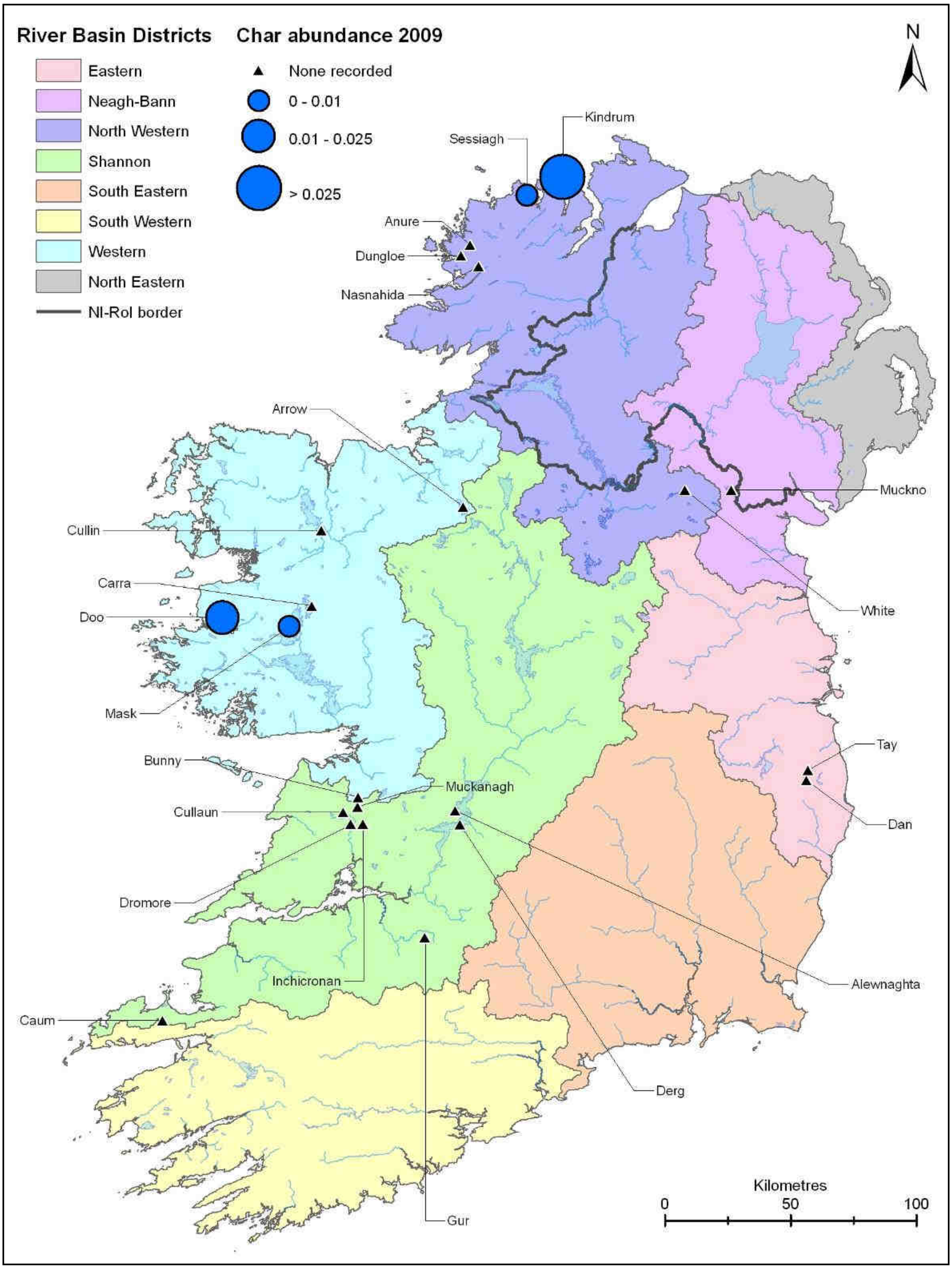

Fig. 4.7. Char distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

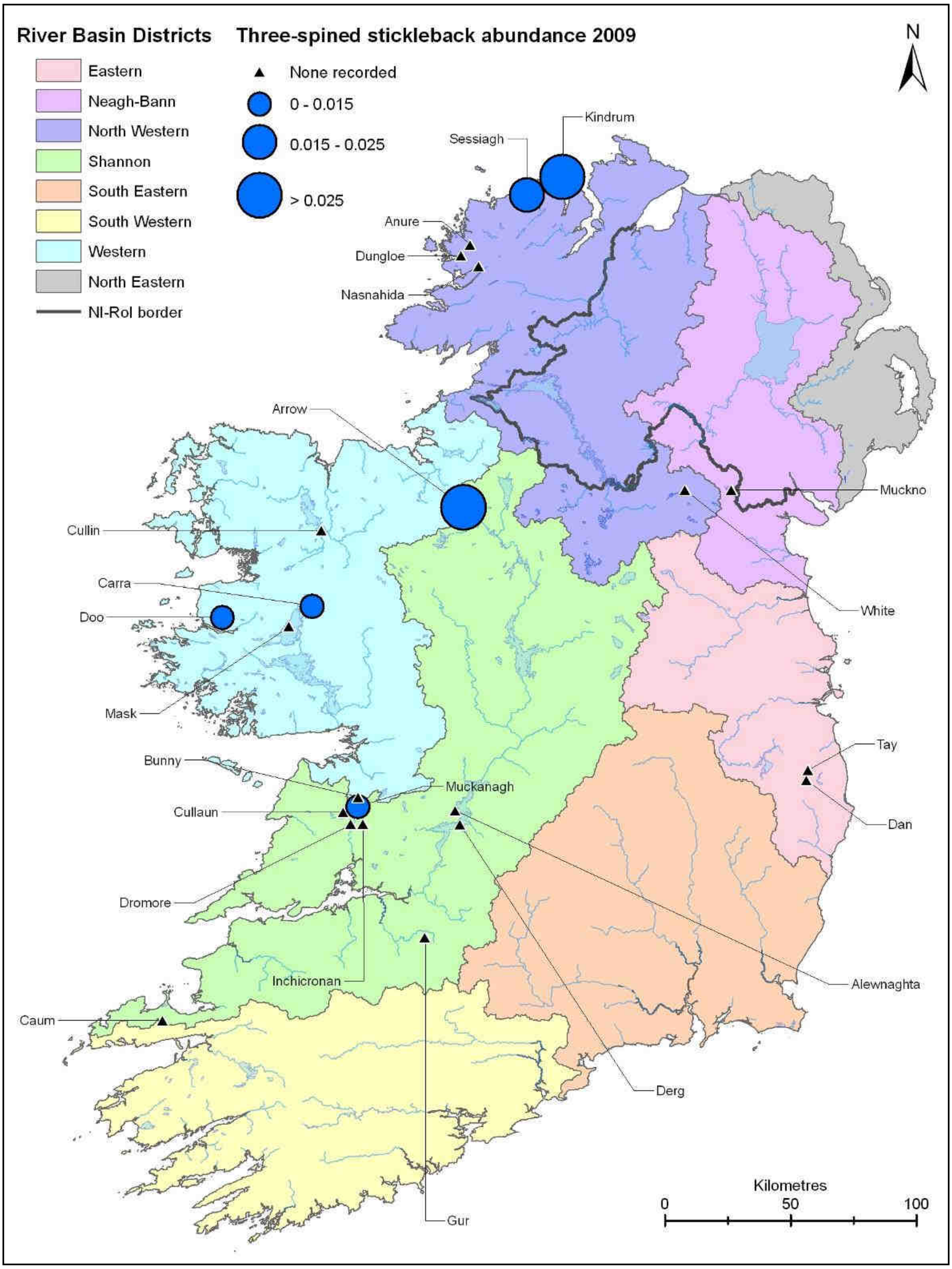

Fig. 4.8. 3-spined stickleback distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

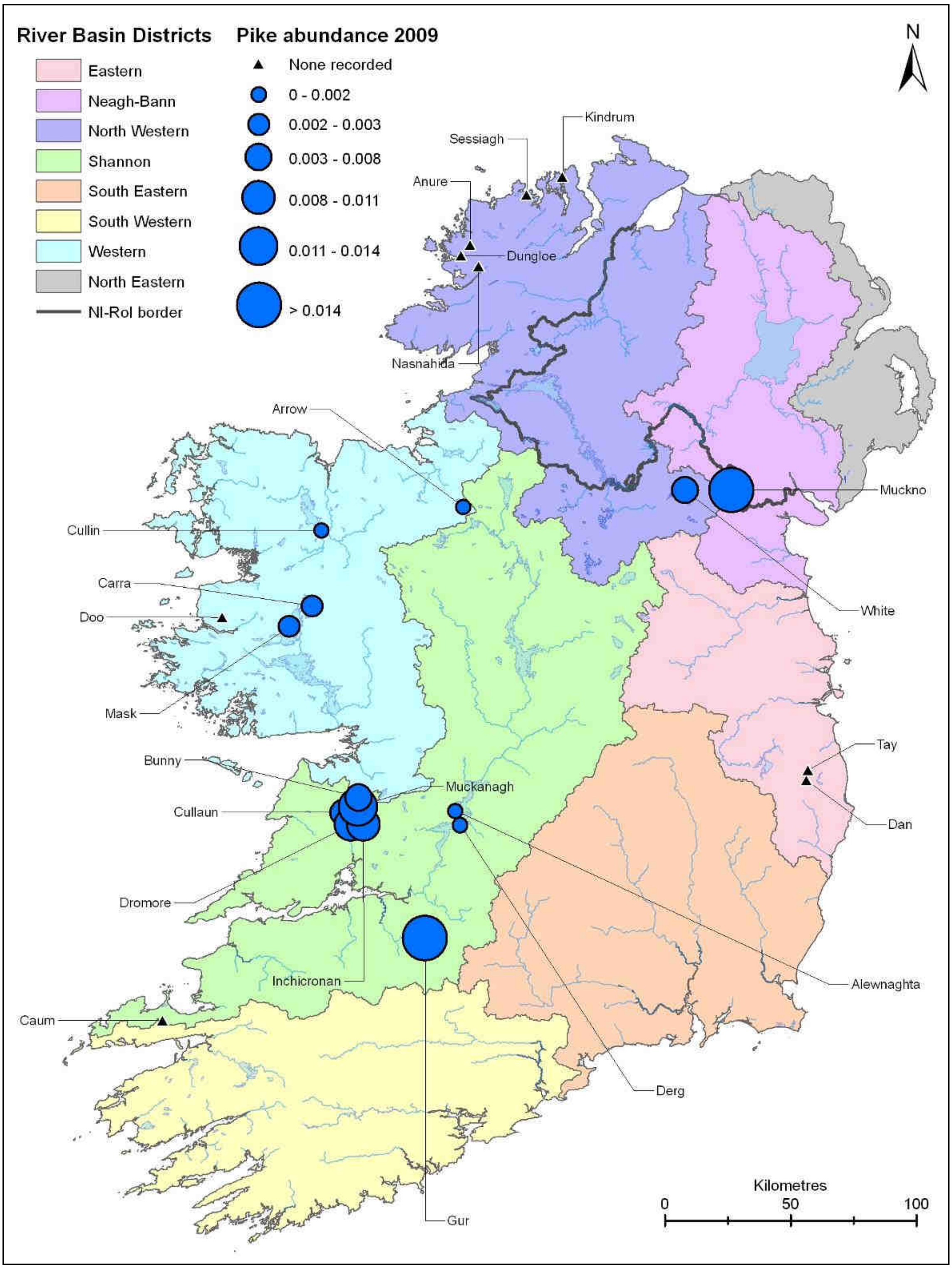

Fig. 4.9. Pike distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

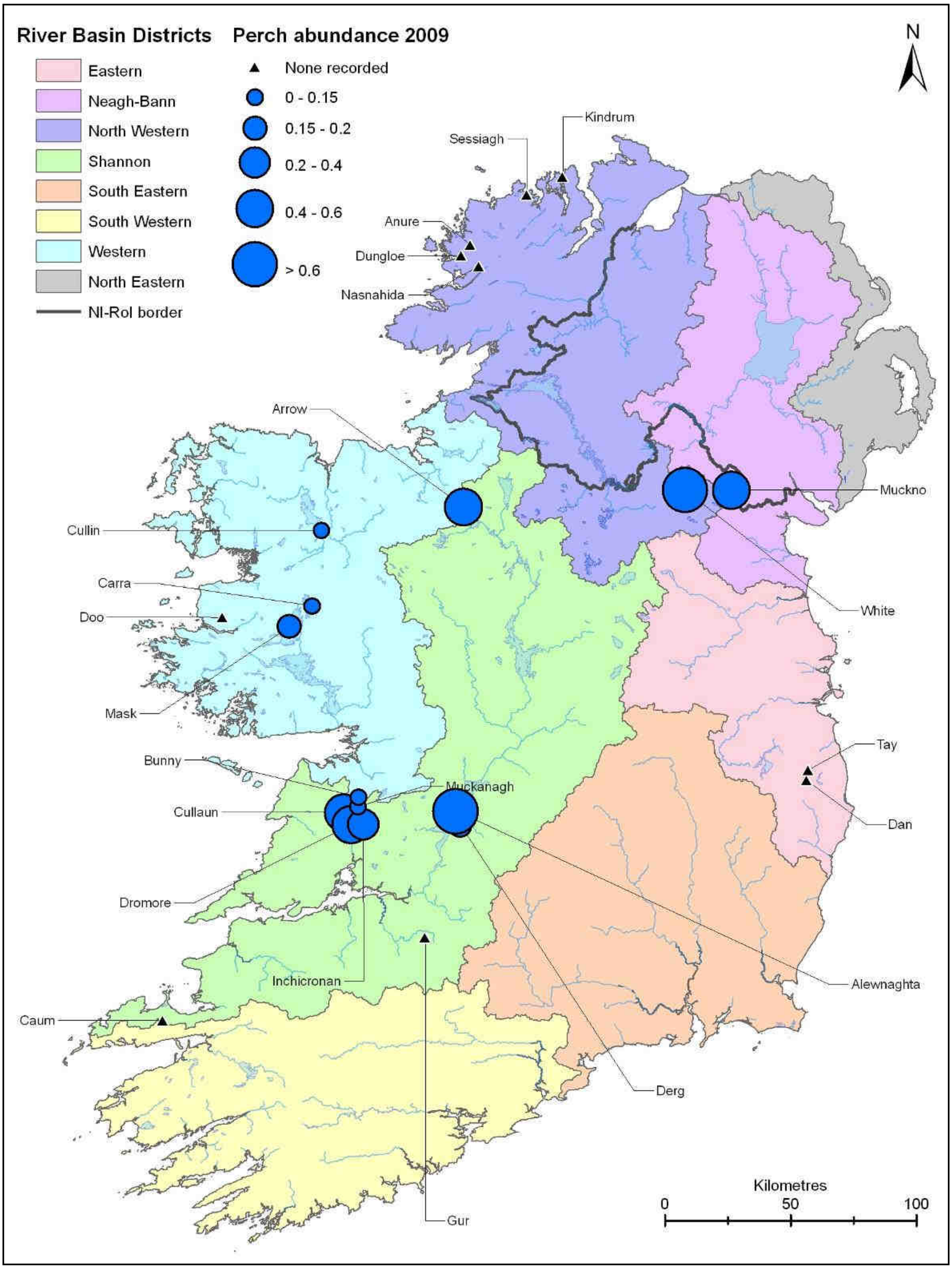

Fig. 4.10. Perch distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

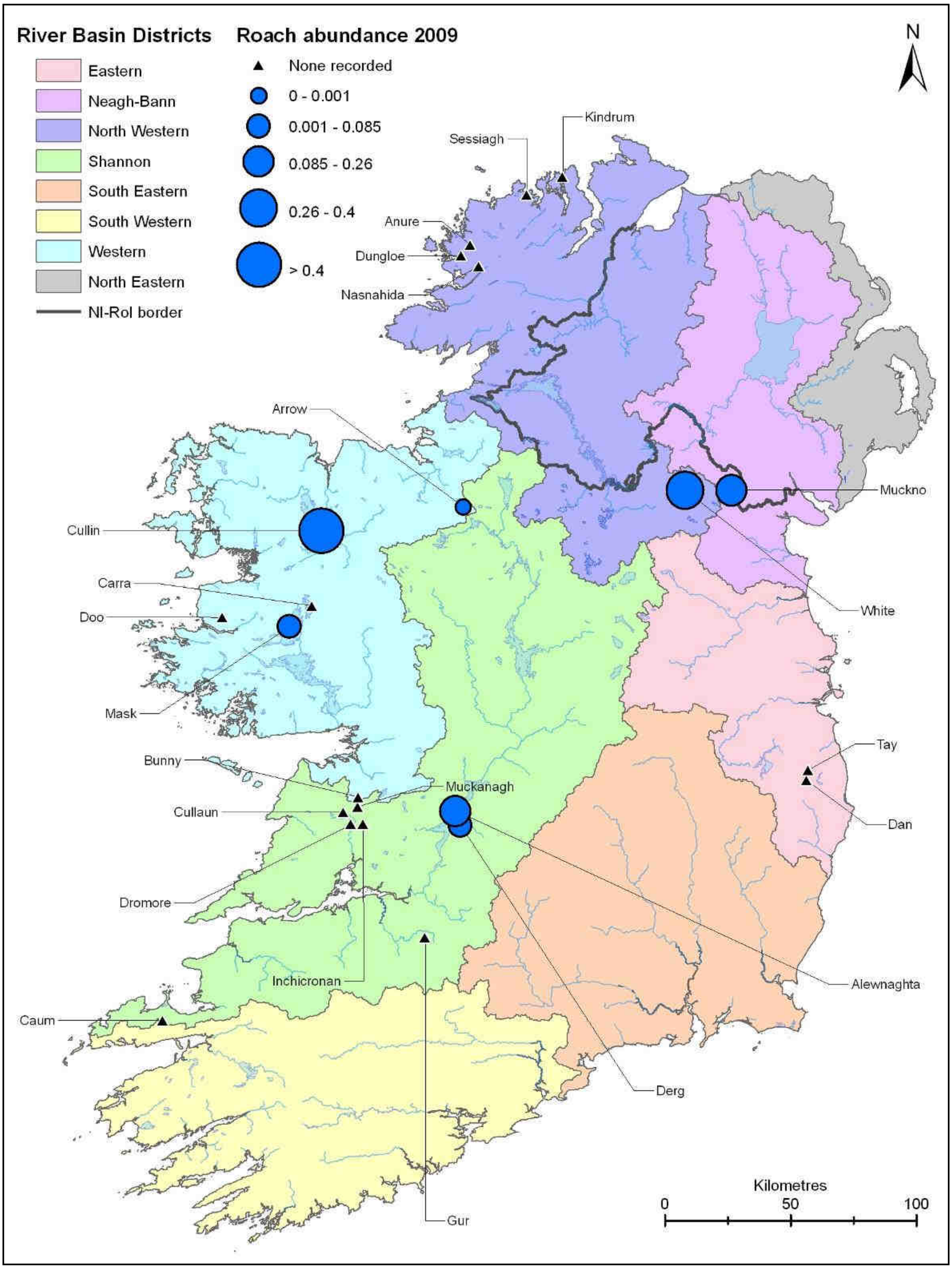

Fig. 4.11. Roach distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

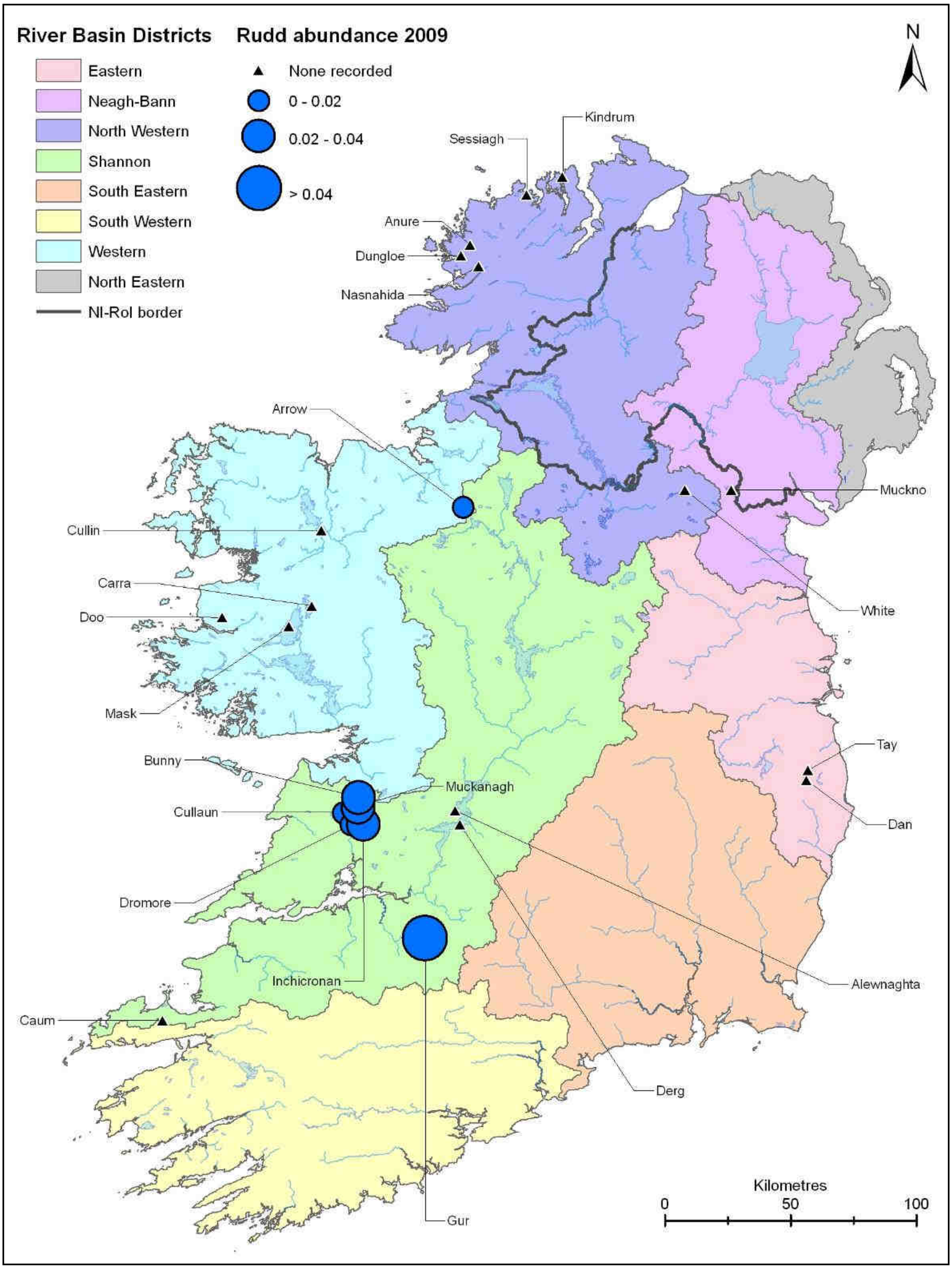

Fig. 4.12. Rudd distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

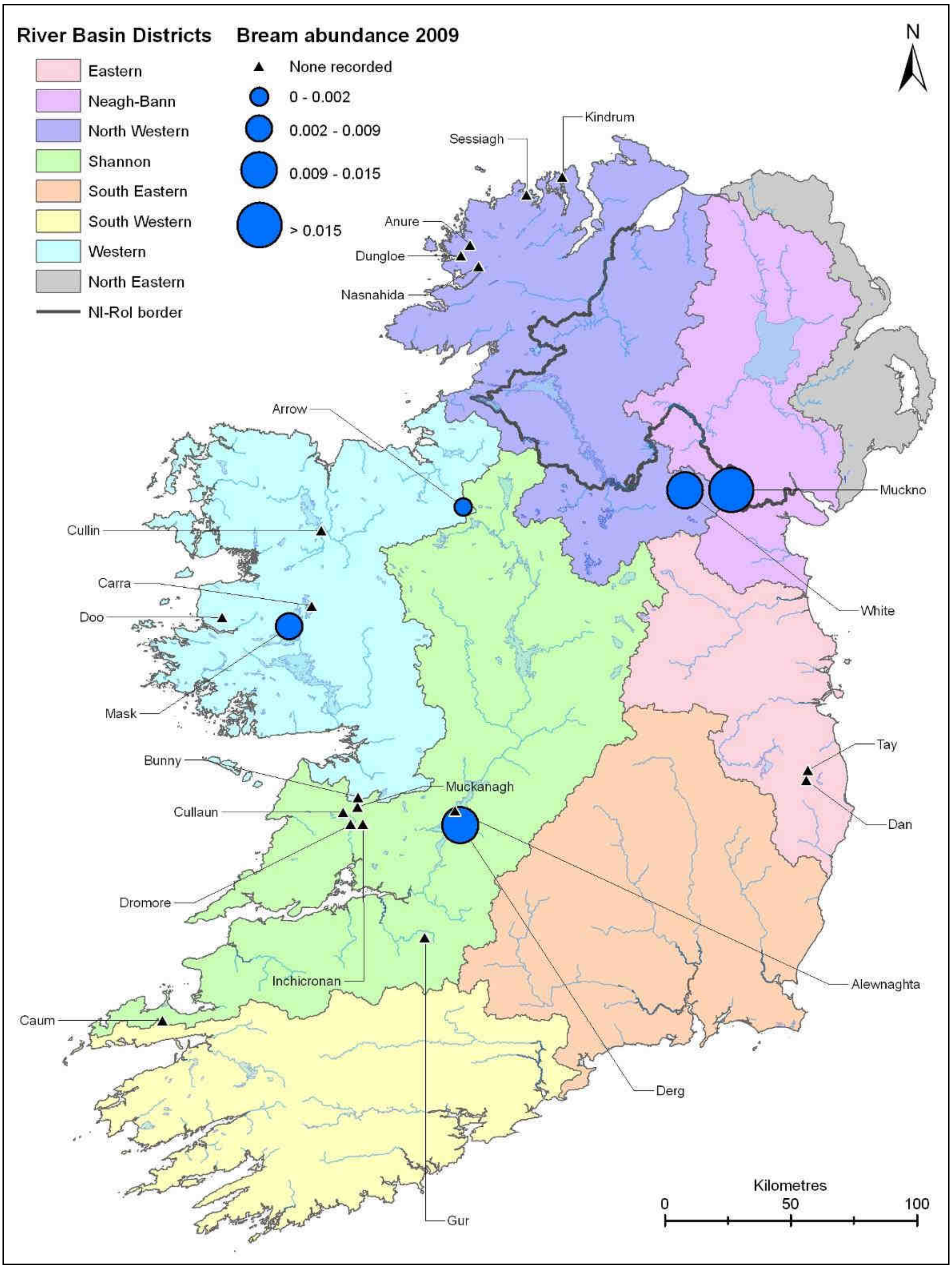

Fig. 4.13. Bream distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

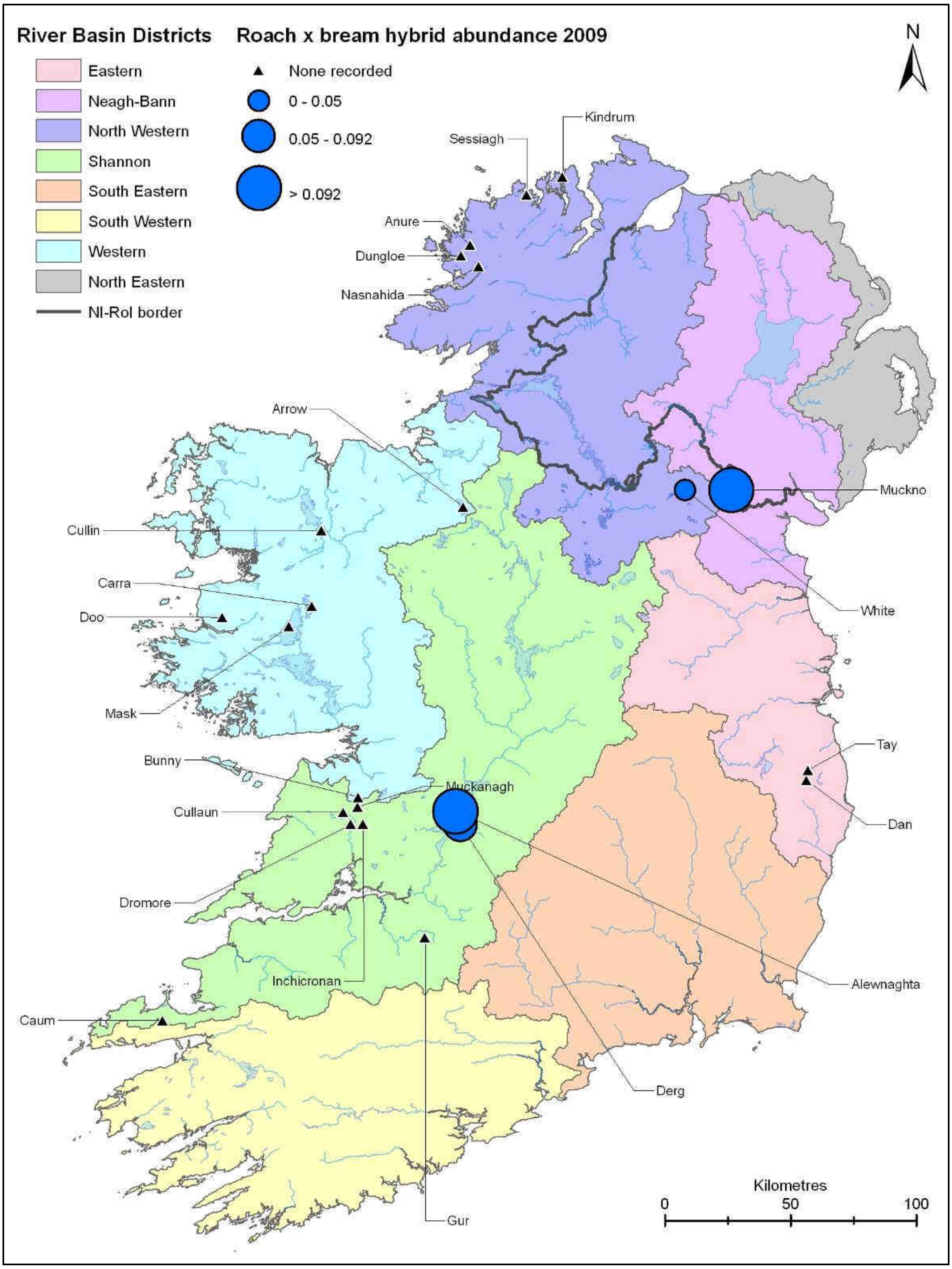

Fig. 4.14. Roach x bream hybrid distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

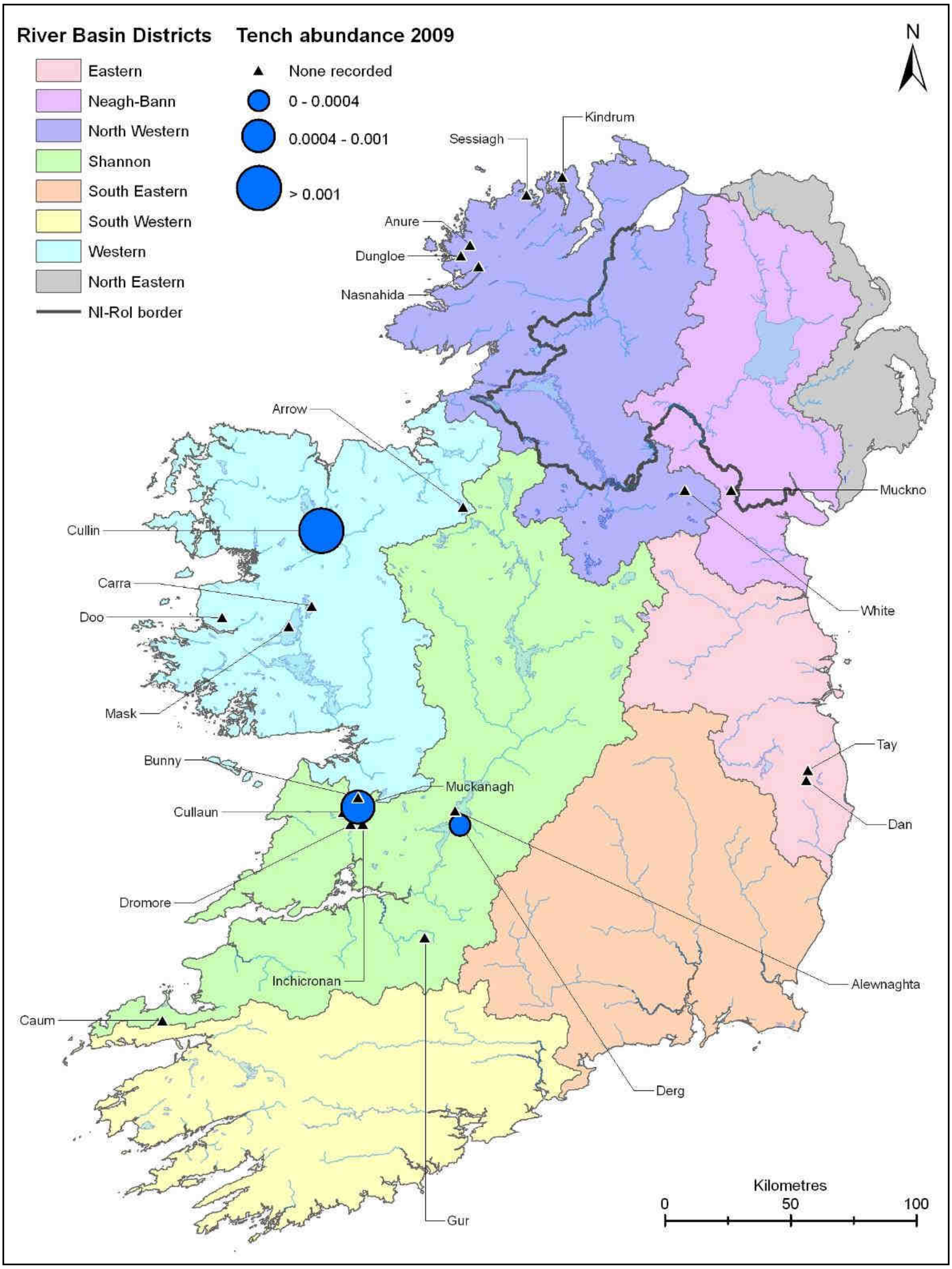

Fig. 4.15. Tench distribution and abundance (CPUE) in lakes surveyed for WFD fish monitoring 2009

4.1.3 Fish abundance and biomass

The abundance (mean CPUE - mean number of fish/m net) and biomass (mean BPUE - mean weight (g) of fish/m of net) of the principal fish species recorded in lakes surveyed during the 2009 surveillance monitoring programme are shown in Figures 4.16 to 4.37. Eel abundance and biomass are shown in Figures 4.16 and 4.17. Lough Anure and Dungloe Lough exhibited the highest abundance of eels amongst the low alkalinity lakes, Lough Sessiagh exhibited the highest amongst the moderately alkaline lakes and Inchicronan Lough exhibited the highest abundance amongst the high alkalinity lakes. Lough Anure and Lough Dan exhibited the highest biomass of eels amongst the low alkalinity lakes, Lough Sessiagh exhibited the highest biomass amongst the moderately alkaline lakes and Lough Muckanagh and Inchicronan Lough exhibited the highest biomass of eels amongst the high alkalinity lakes. Overall Inchicronan Lough exhibited both the highest abundance and the highest biomass of eels amongst the 23 lakes surveyed during 2009 (Figs. 4.16 and 4.17).

Brown trout abundance and biomass are shown in Figures 4.18 and 4.19 respectively. Overall the highest abundance of brown trout amongst all lakes surveyed was recorded in Lough Nasnahida, a low alkalinity lake in Co. Donegal in the NWIRBD (Fig. 4.18), whereas the highest biomass of brown trout amongst all lakes surveyed was recorded in Kindrum Lough (moderate alkalinity), also in Co. Donegal (Fig. 4.19).

Sea trout were only recorded in two lakes out of all the lakes surveyed in 2009, with both the highest abundance and highest biomass in Doo Lough (Figs. 4.20 and 4.21).

Char were recorded in four lakes (Kindrum, Sessiagh, Doo and Mask), with Kindrum Lough (moderate alkalinity) exhibiting both the highest abundance and the highest biomass (Figs. 4.22 and 4.23).

Perch were recorded in 13 out of the 23 lakes surveyed during 2009. There were no perch recorded in any of the low alkalinity lakes. Lough Alewnaghta exhibited the highest abundance of perch in the moderate alkalinity class, and also had the highest perch abundance amongst all lakes surveyed in 2009. Lough Arrow exhibited the highest abundance of perch amongst high alkalinity lakes. Lough Muckno and Dromore Lough exhibited the highest biomass of perch in the moderate and high alkalinity lakes respectively (Figs. 4.24 and 4.25).

Similar to perch, roach occurred in the moderate and high alkalinity lakes only. White Lough exhibited both the highest abundance and the highest biomass of roach in the moderate alkalinity class and Lough Cullin recorded both the highest abundance and the highest biomass of roach in the high alkalinity lakes (Figs. 4.26 and 4.27).

Pike were recorded in 14 lakes, again only with moderate and high alkalinity. Lough Muckno exhibited both the highest abundance and the highest biomass of pike in the moderate alkalinity lakes.

Lough Gur exhibited the highest abundance of pike in the high alkalinity lakes and Inchicronan Lough exhibited the highest biomass (Figs. 4.28 and 4.29).

Bream were captured in five lakes, all with moderate or high alkalinity. Lough Muckno exhibited both the highest abundance and the highest biomass of bream in the moderate alkalinity lakes whilst Lough Derg exhibited both the highest abundance and the highest biomass of bream in the high alkalinity lakes (Figs. 4.30 and 4.31)

Tench were recorded in three lakes, all of which were high alkalinity. Lough Cullin exhibited the highest abundance of tench among the three lakes. A biomass value was not obtained for Lough Cullin due to escapement of fish from the nets during retrieval (Figs. 4.32 and 4.33).

Rudd were captured in seven lakes, again all of which were high alkalinity. The highest abundance and the highest biomass of rudd were recorded on Lough Gur (Figs. 4.34 and 4.35).

Roach x bream hybrids were recorded in four lakes. The highest abundance and the highest biomass of roach x hybrids were recorded on Lough Derg (high alkalinity) followed by Lough Alewnaghta (moderate alkalinity) (Figs. 4.36 and 4.37).

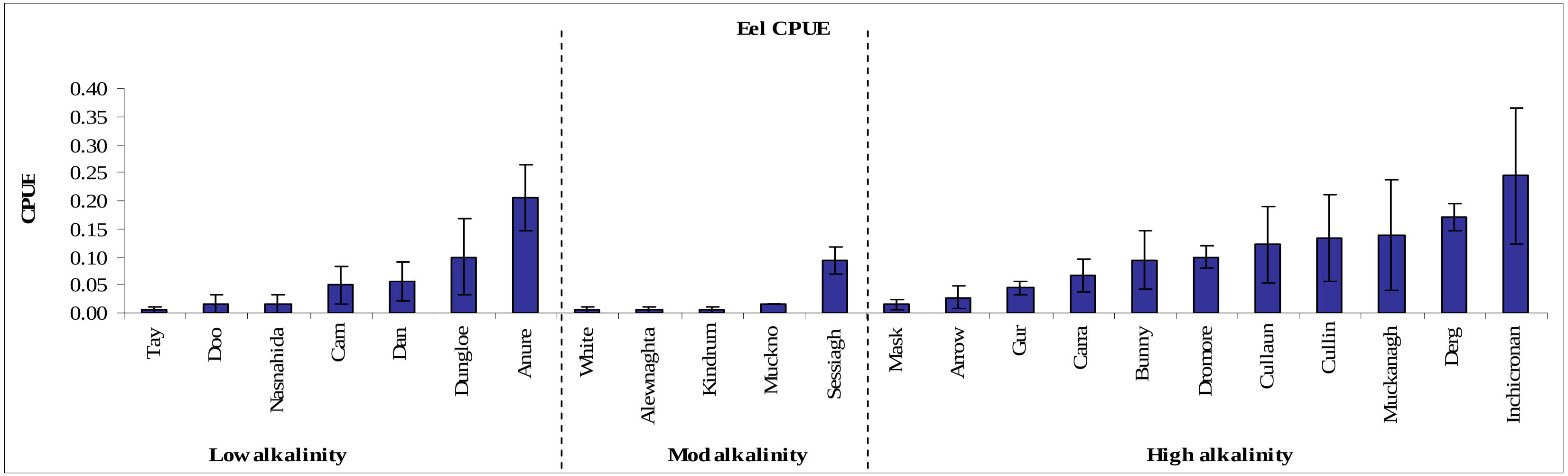

Fig. 4.16. Eel abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

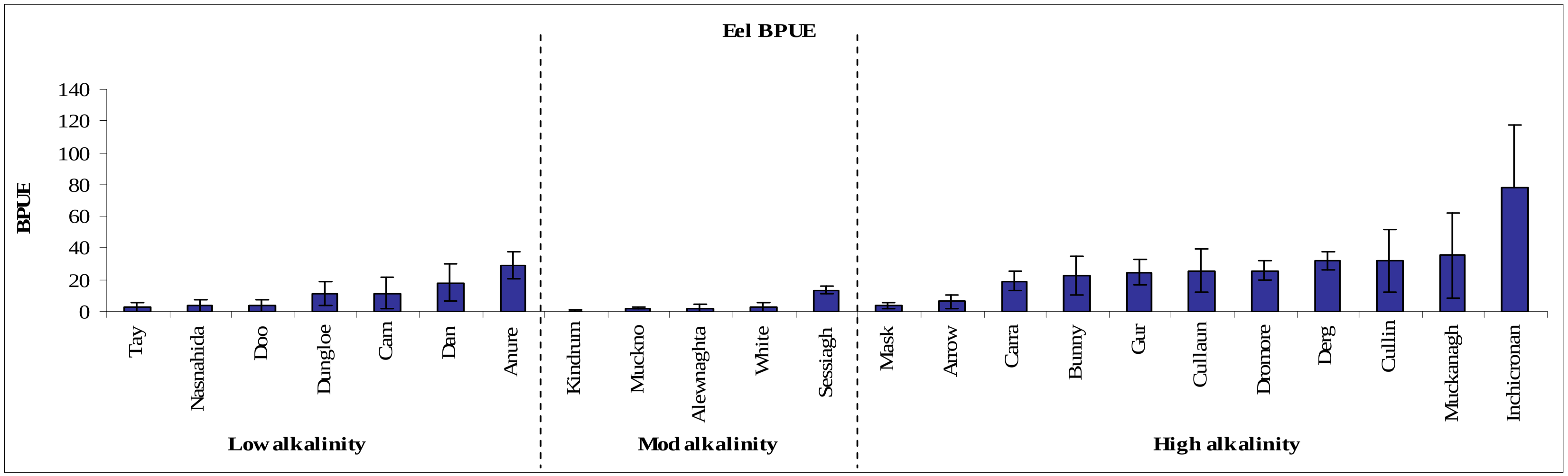

Fig. 4.17. Eel biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

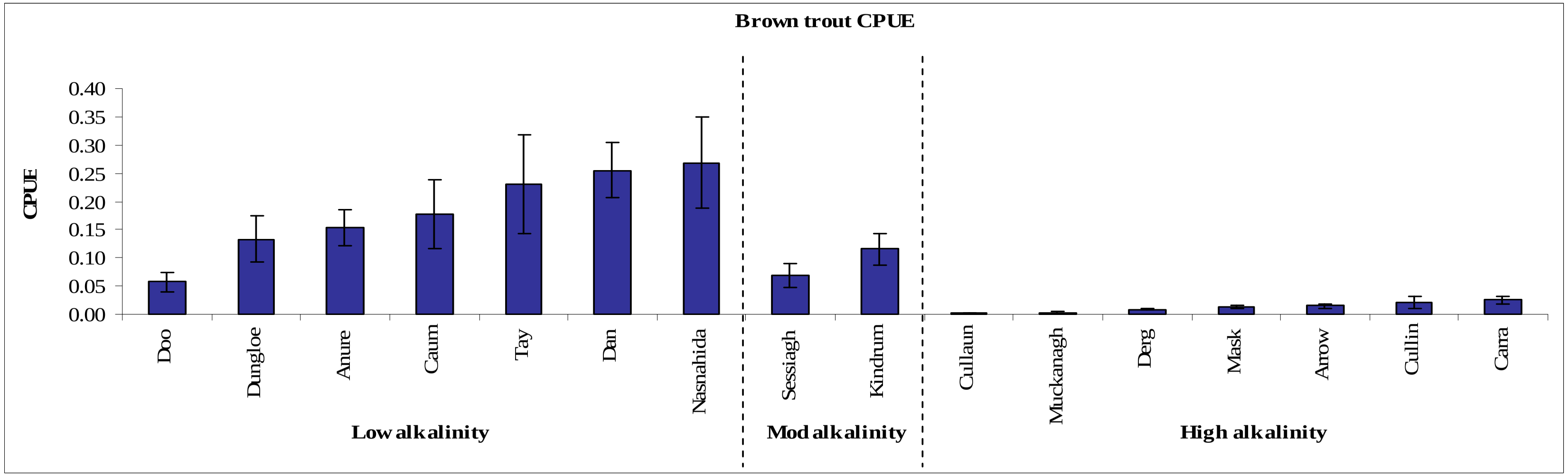

Fig. 4.18. Brown trout abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

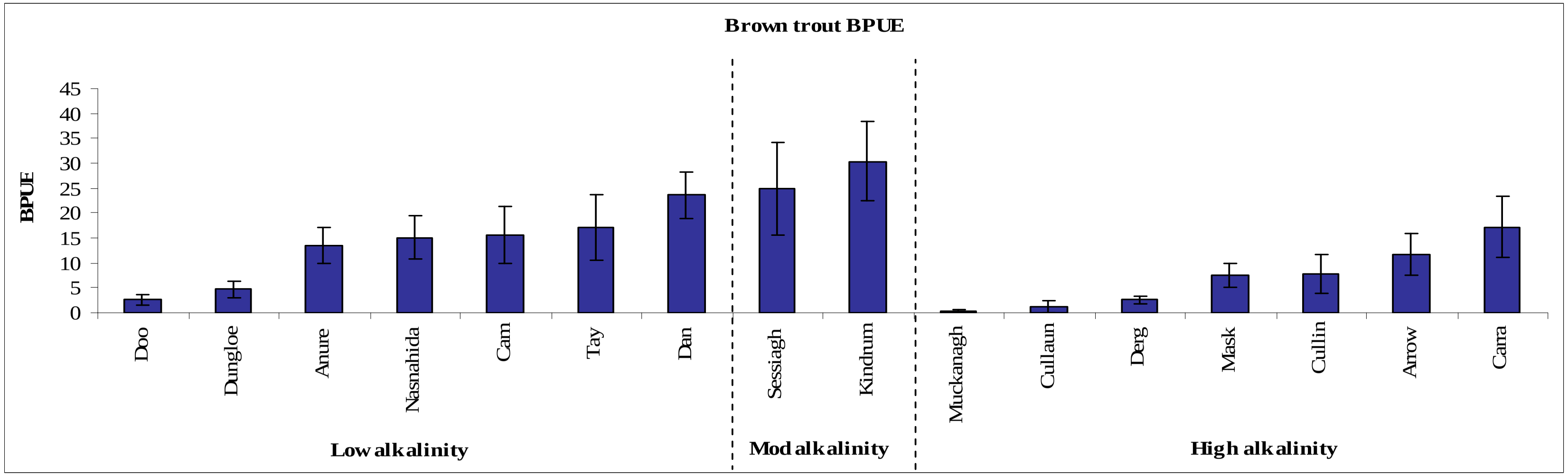

Fig. 4.19. Brown trout biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

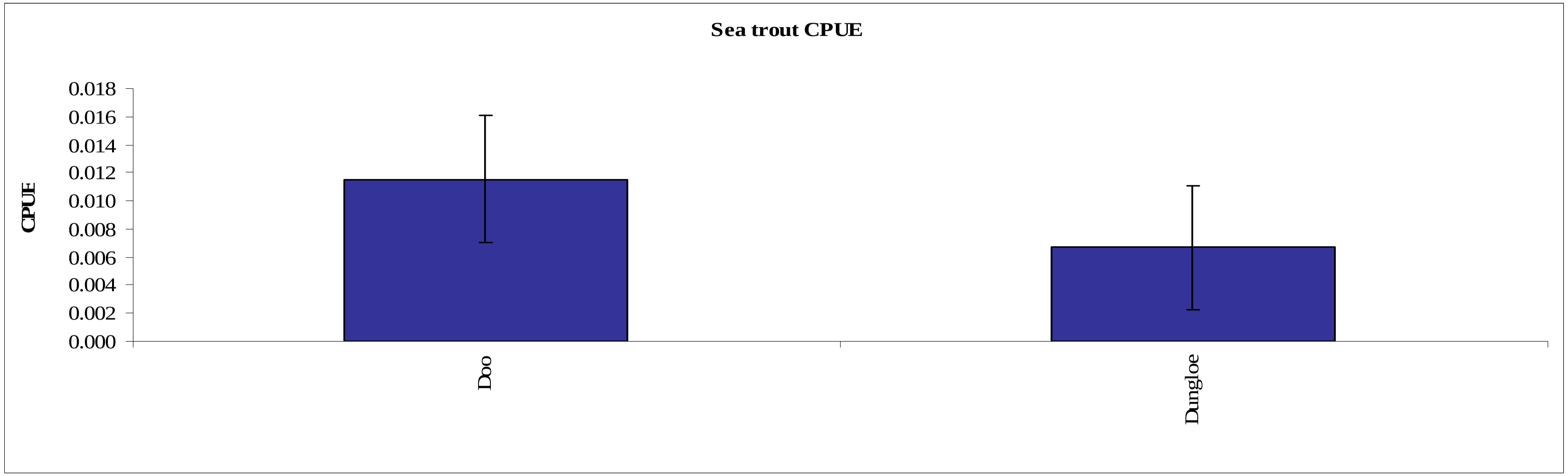

Fig. 4.20. Sea trout abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

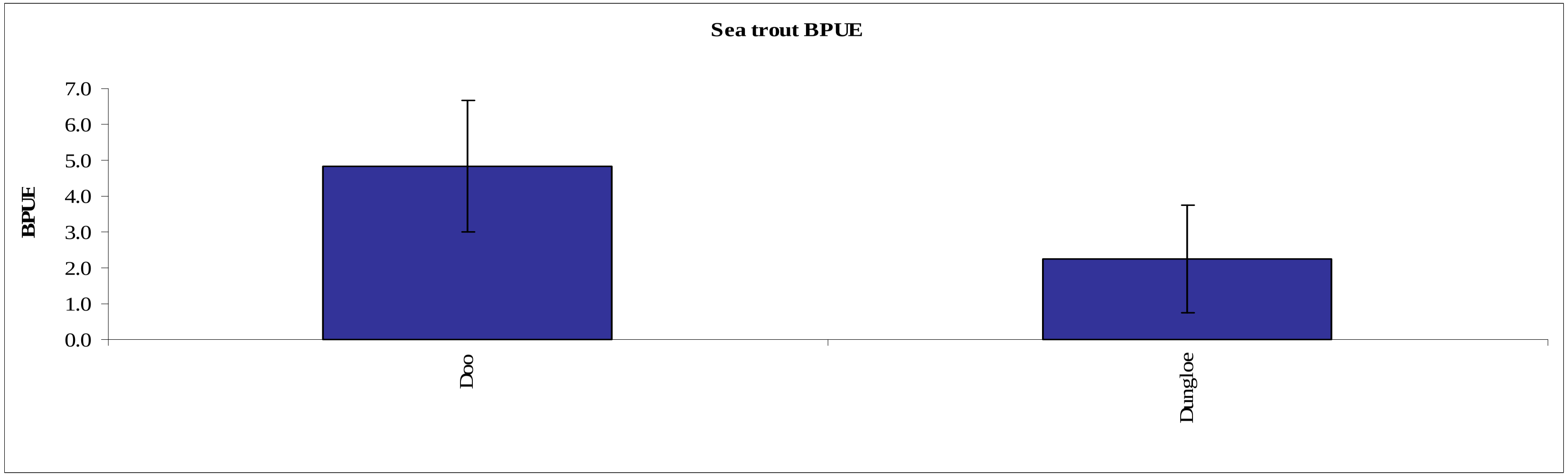

Fig. 4.21. Sea trout biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

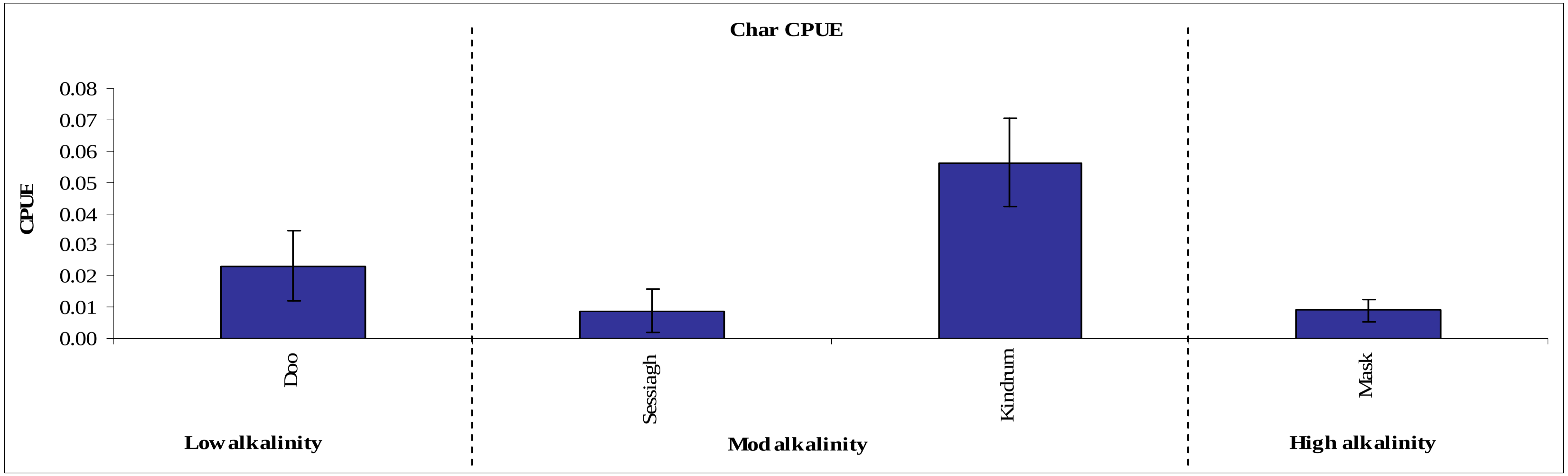

Fig. 4.22. Char abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

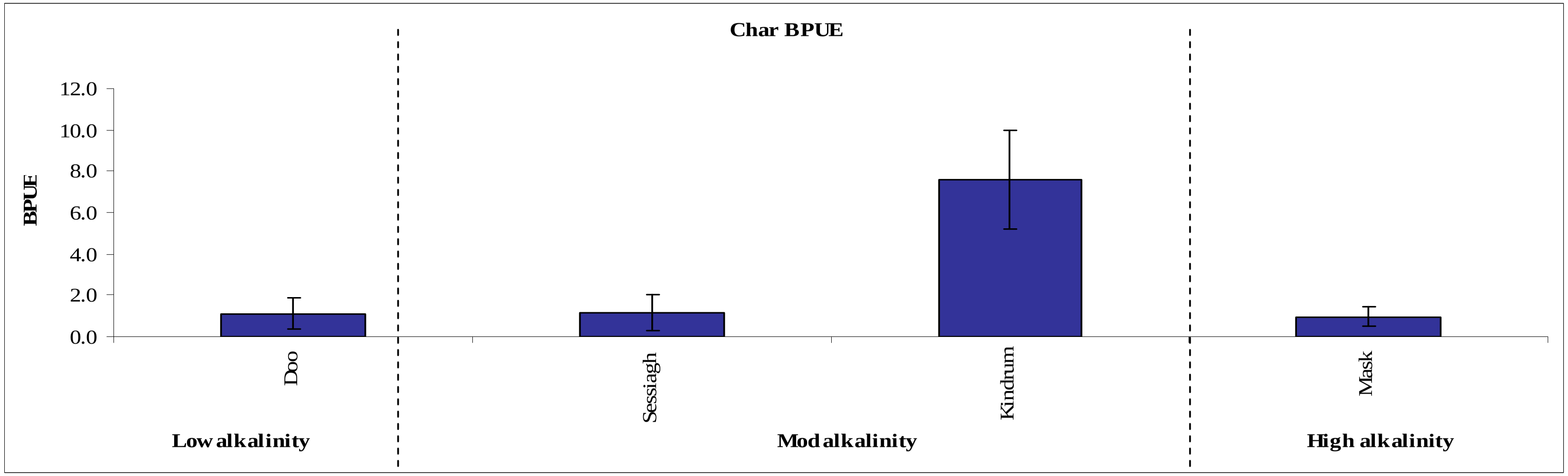

Fig. 4.23. Char biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

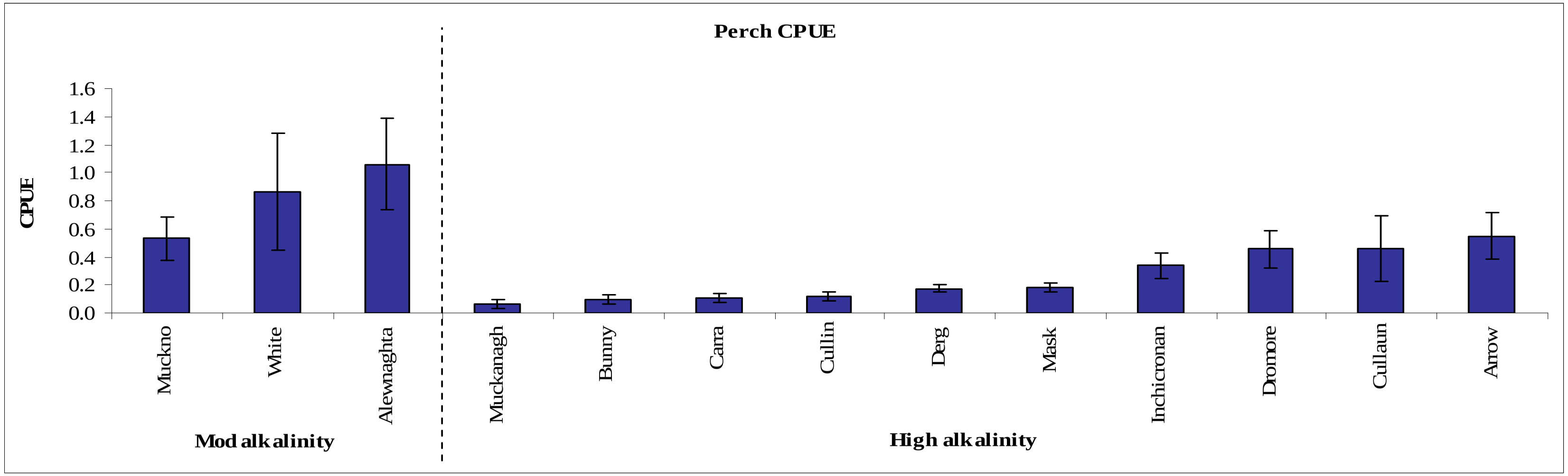

Fig. 4.24. Perch abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

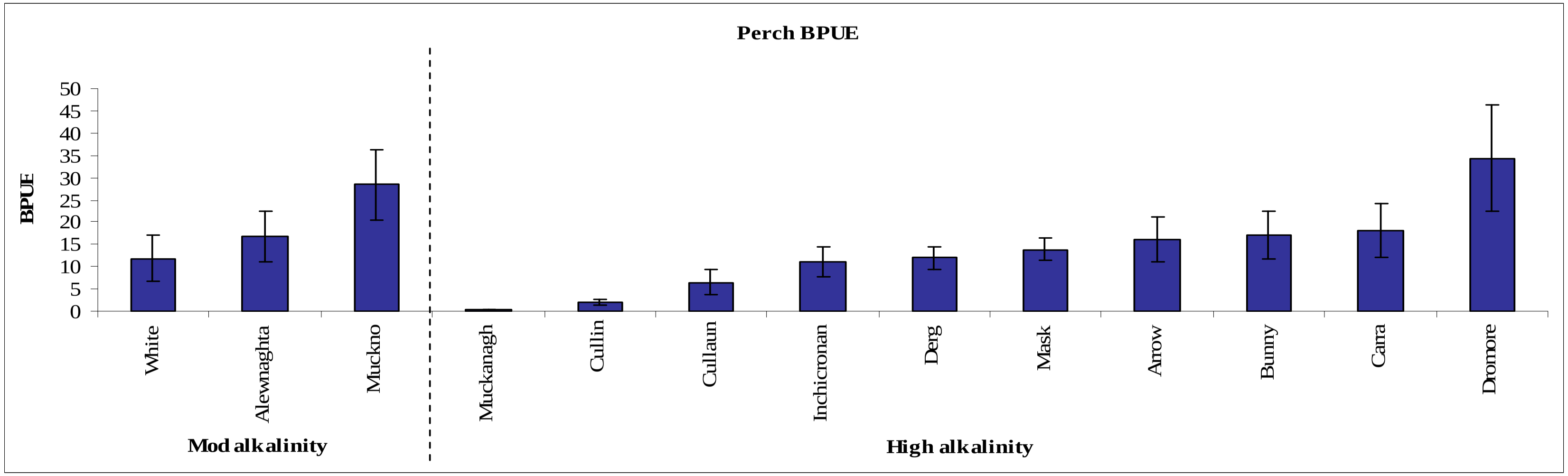

Fig. 4.25. Perch biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

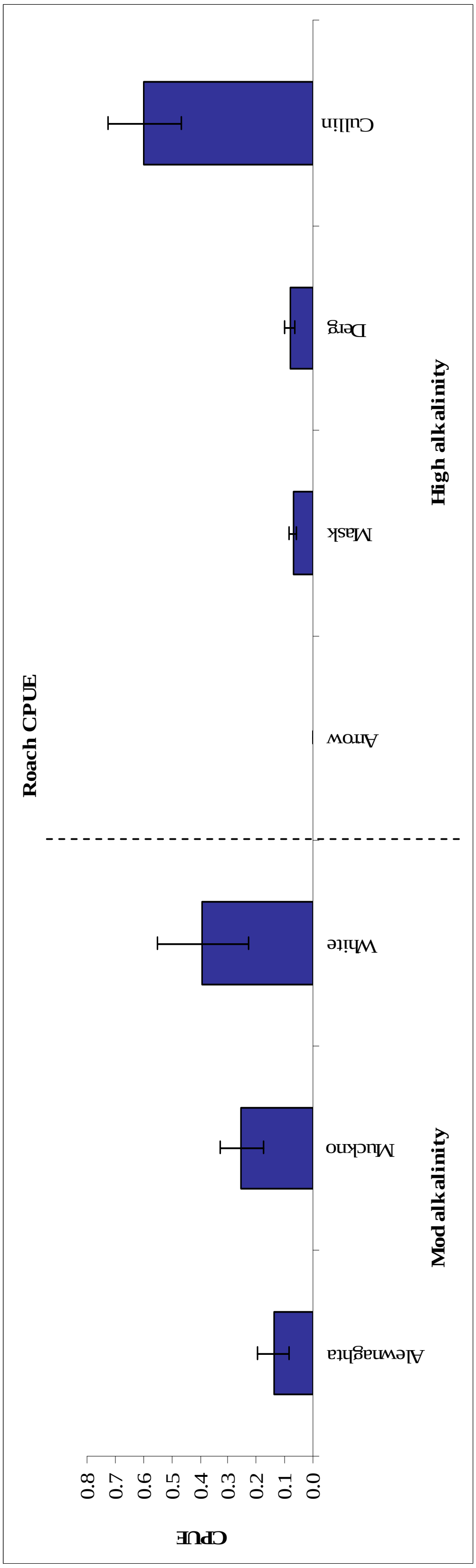

Fig. 4.26. Roach abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

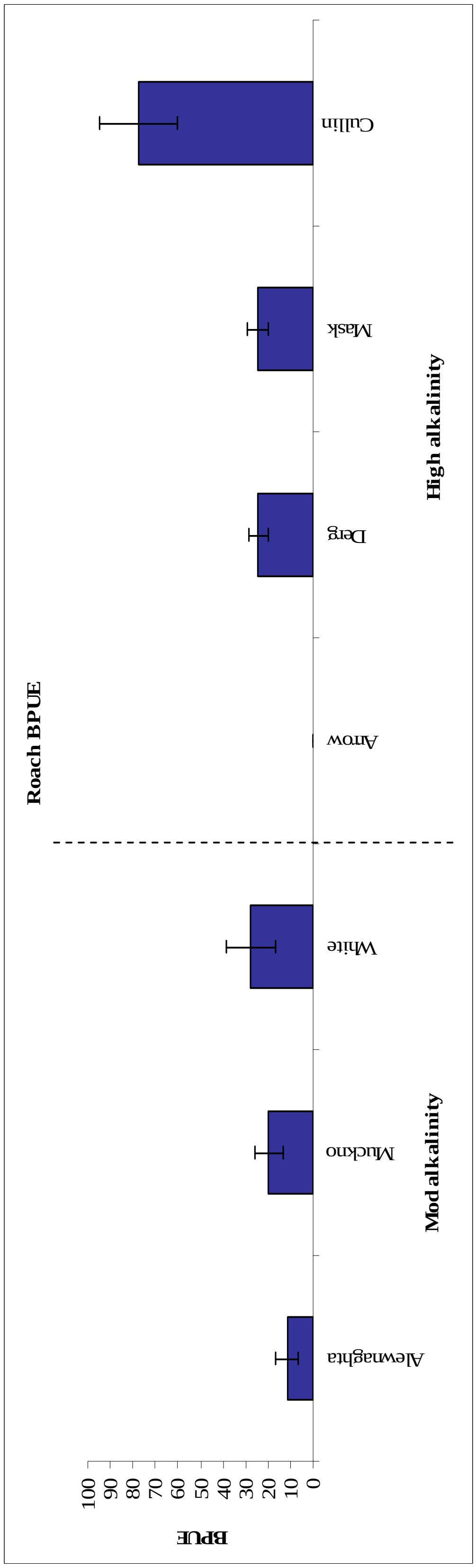

Fig. 4.27. Roach biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

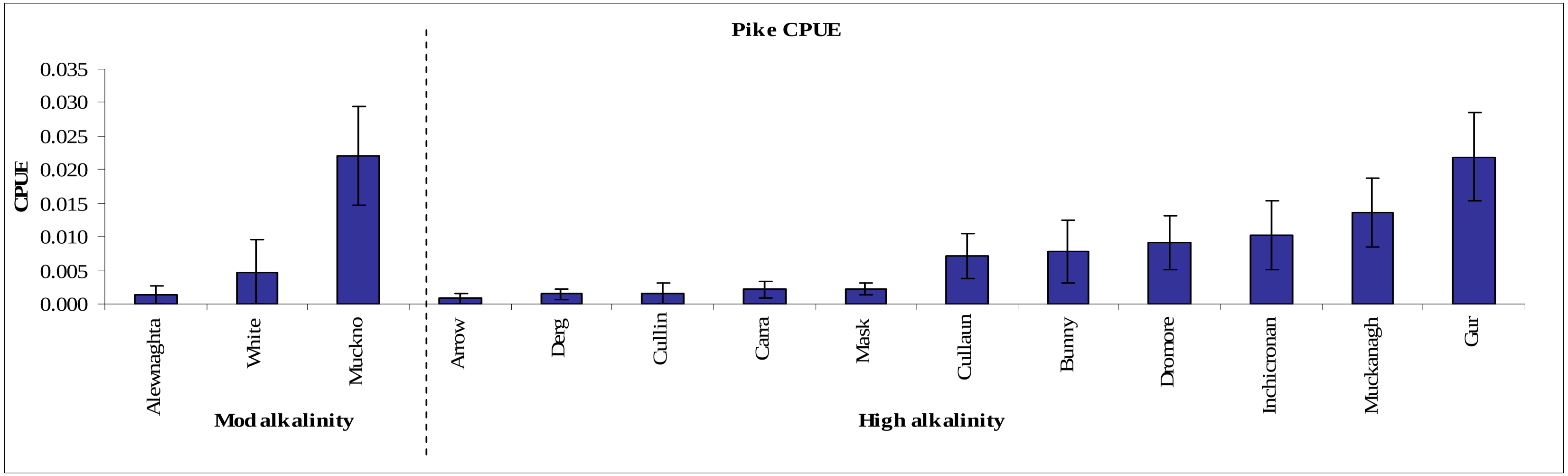

Fig. 4.28. Pike abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

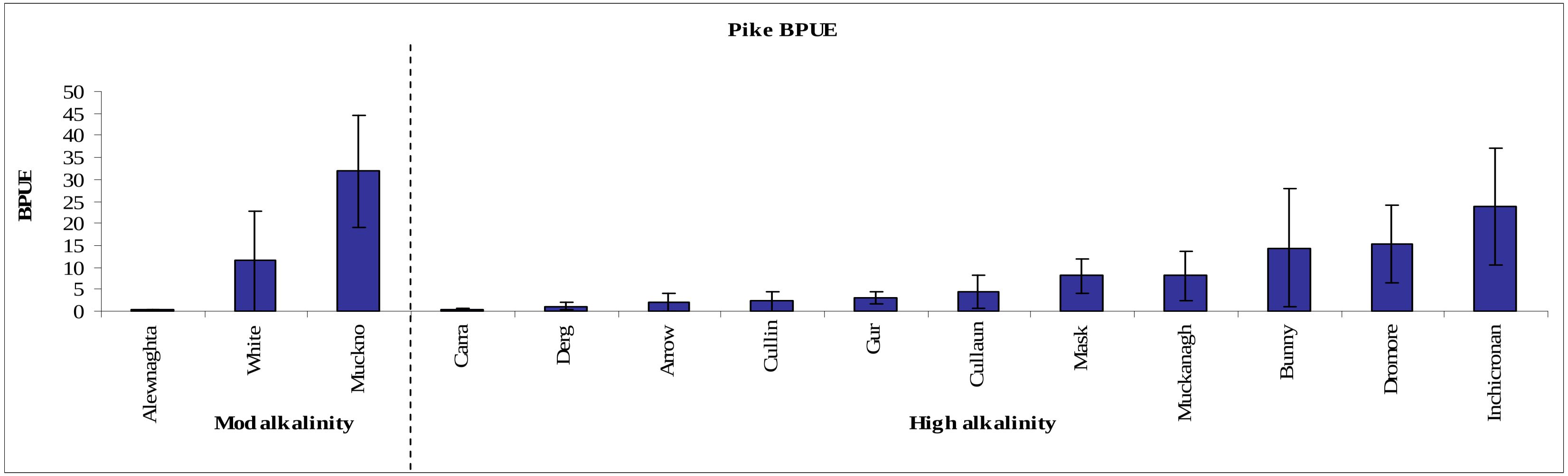

Fig. 4.29. Pike biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

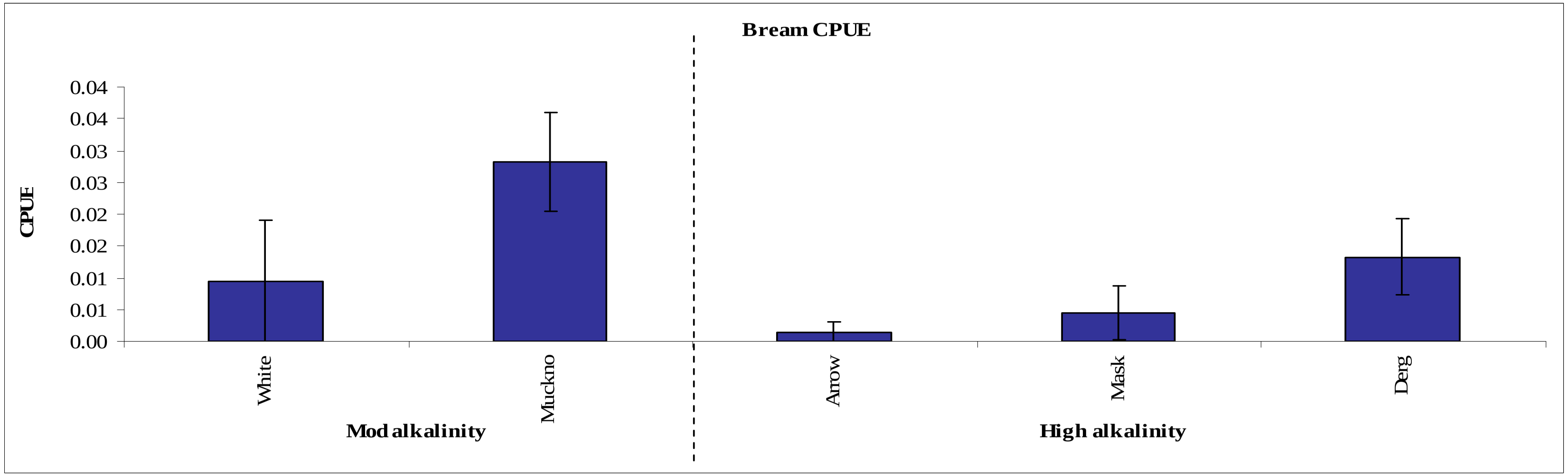

Fig. 4.30. Bream abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

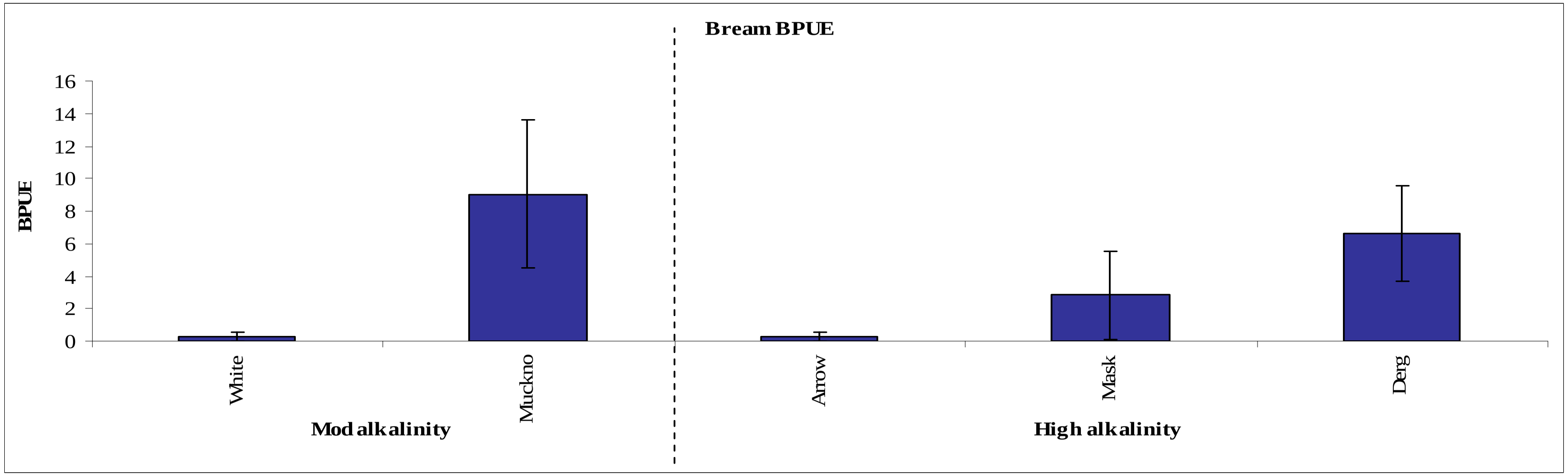

Fig. 4.31. Bream biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

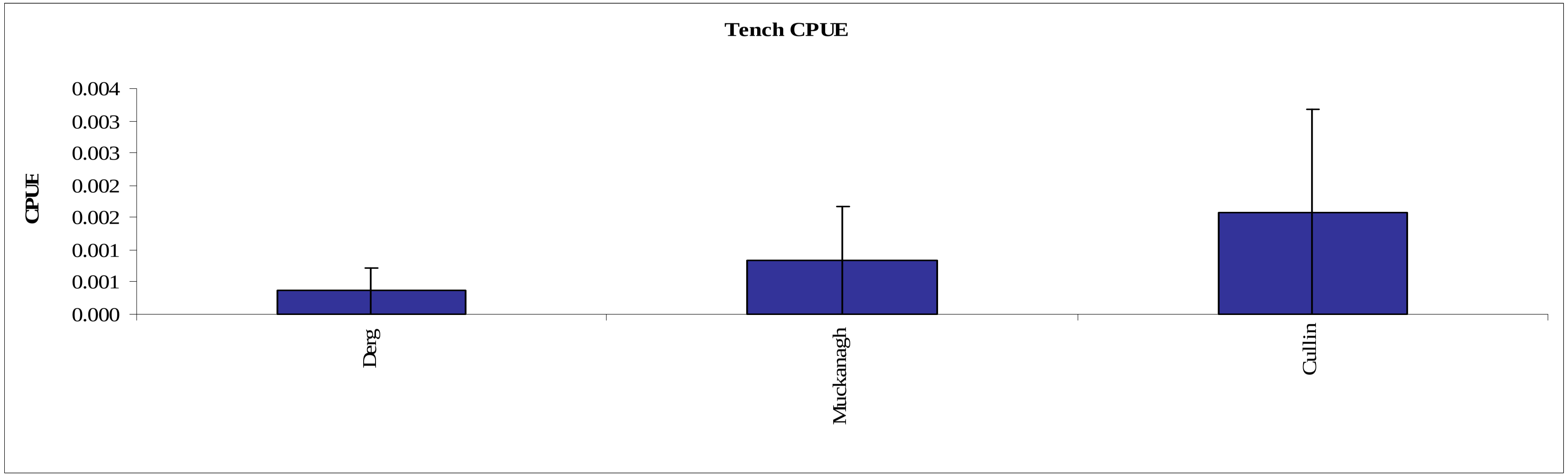

Fig. 4.32. Tench abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

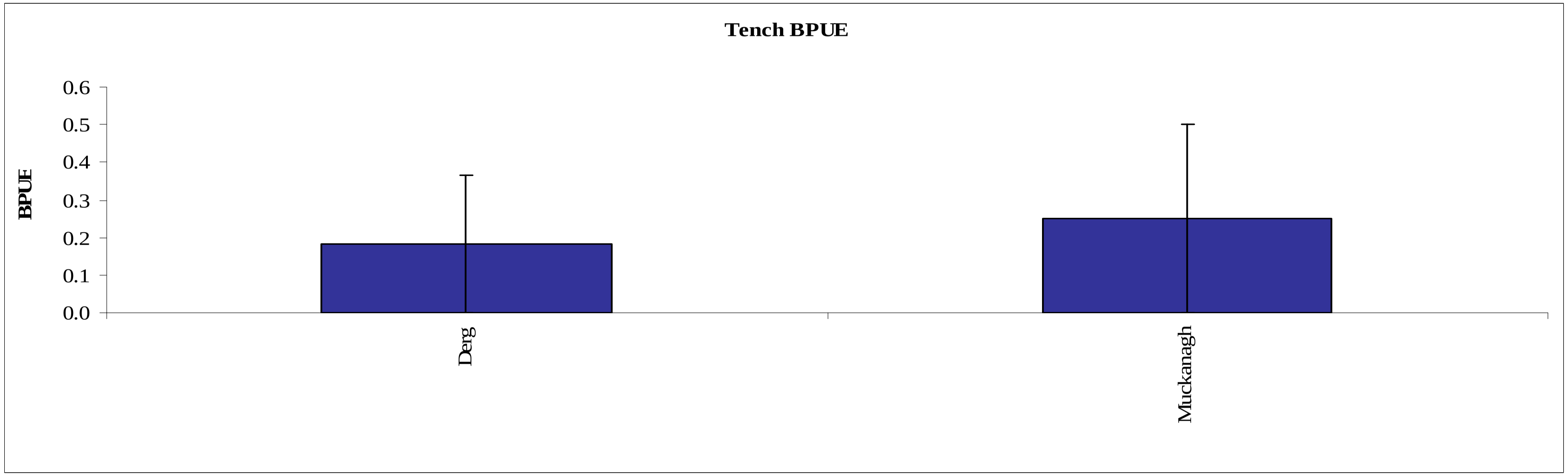

Fig. 4.33. Tench biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

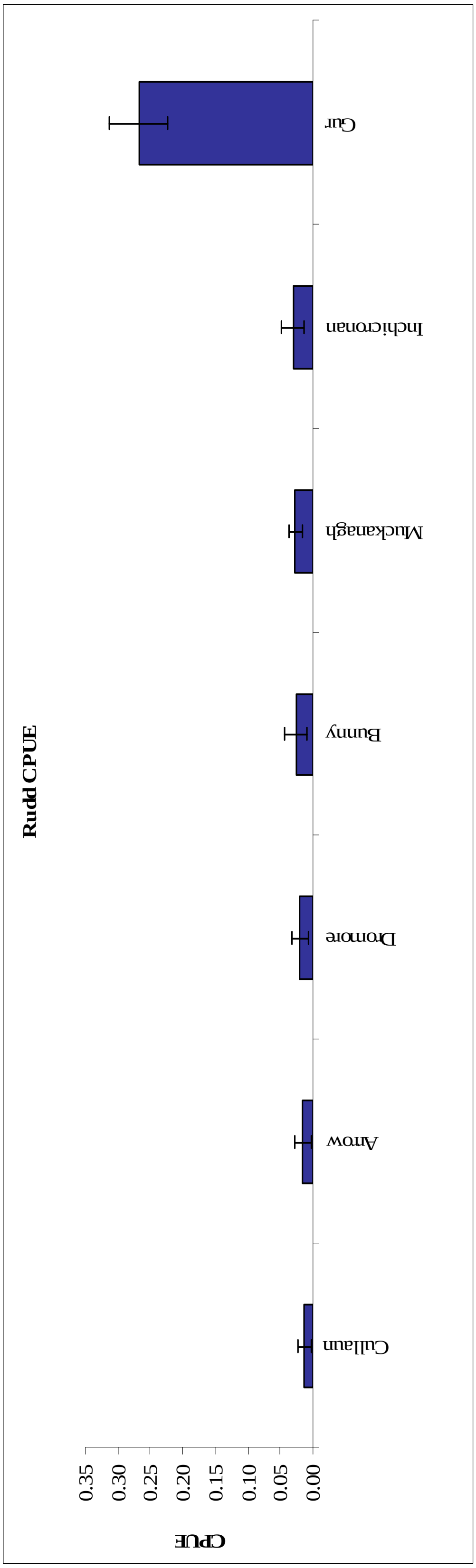

Fig. 4.34. Rudd abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

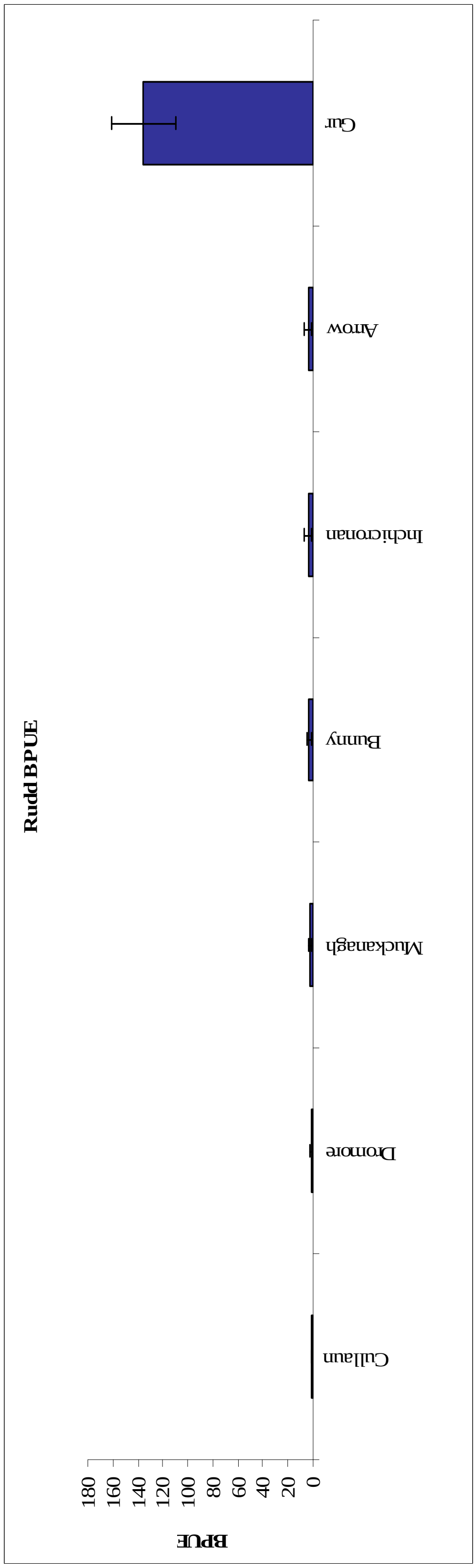

Fig. 4.35. Rudd biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

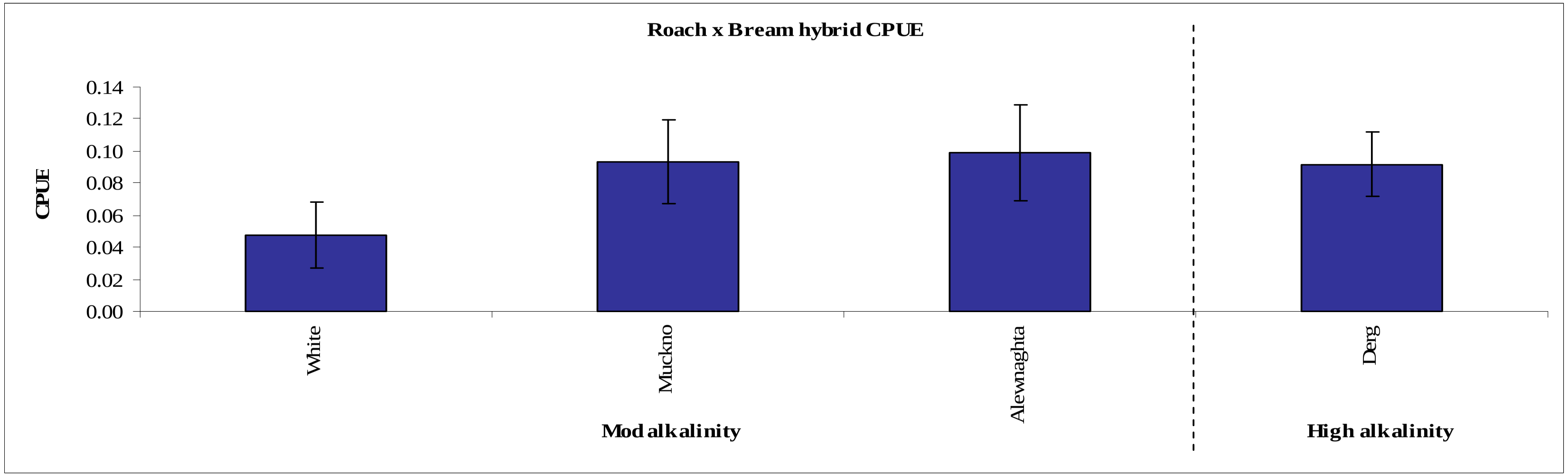

Fig. 4.36. Roach x bream abundance (CPUE – mean (±SE) no. fish/m net) in lakes surveyed for WFD fish monitoring 2009

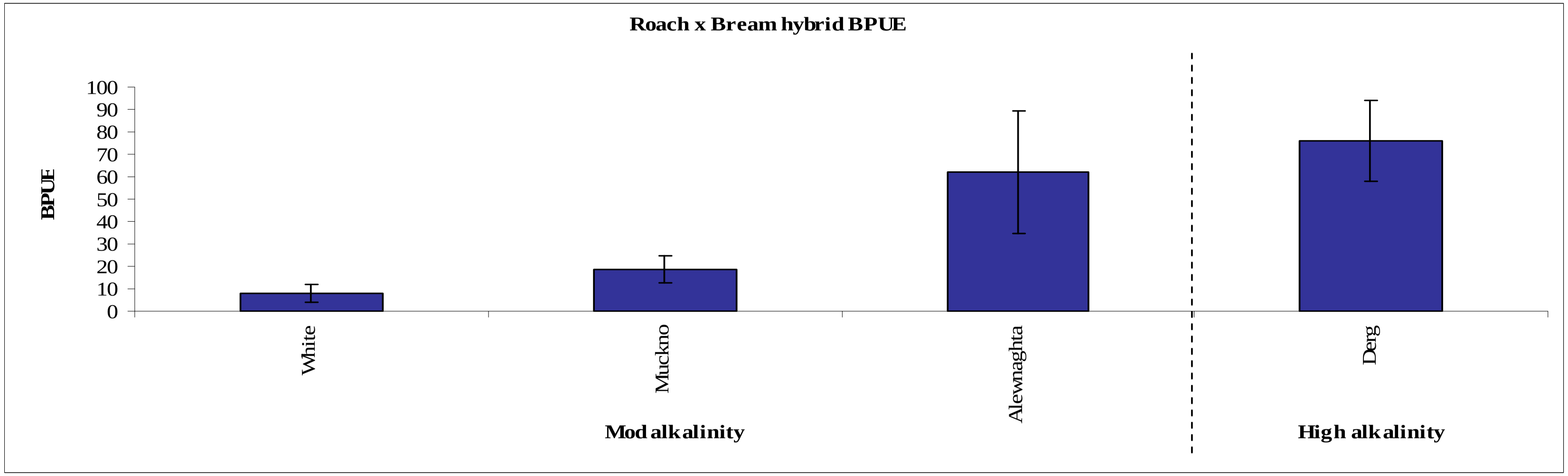

Fig. 4.37. Roach x bream biomass (BPUE – mean (±SE) weight (g) fish/m net) in lakes surveyed for WFD fish monitoring 2009

4.1.4 Fish growth

4.1.4.1 Growth of brown trout, perch and roach

Scales from 730 brown trout (16 lakes), 478 roach (6 lakes), 167 rudd (7 lakes), 67 bream (5 lakes), otoliths from 63 char (4 lakes) and opercular bones from 1,339 perch (13 lakes) were examined for age and growth analysis. 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 from each lake present were back-calculated and growth curves plotted (Figs. 4.38 to 4.40). Details of back calculated lengths at age for brown trout, perch and roach respectively are given in Appendices 3, 4 and 5.

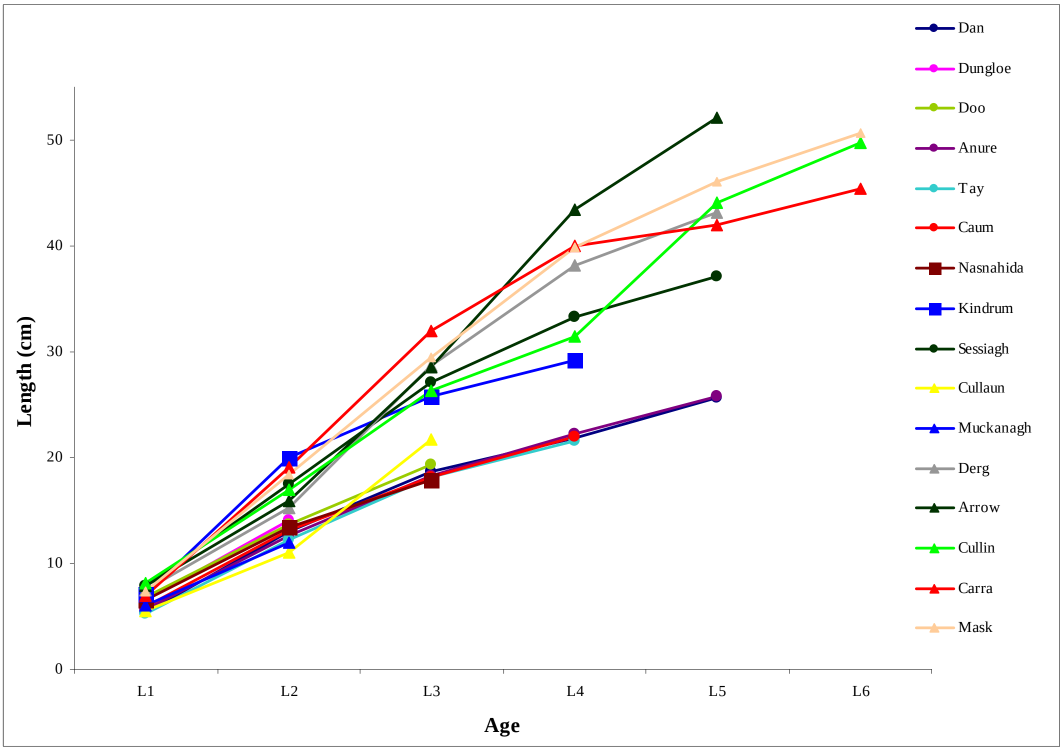

Fig. 4.38. Mean length at age of brown trout in lakes surveyed for WFD fish monitoring 2009 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

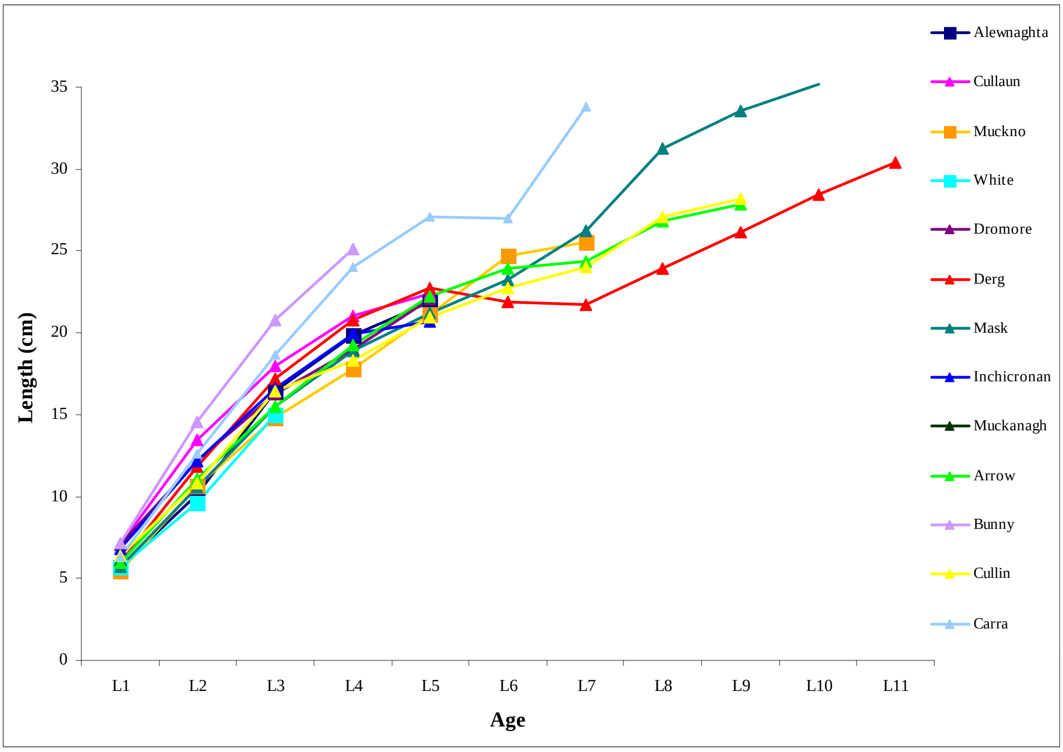

Fig. 4.39. Mean length at age of perch in lakes surveyed for WFD fish monitoring 2009 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

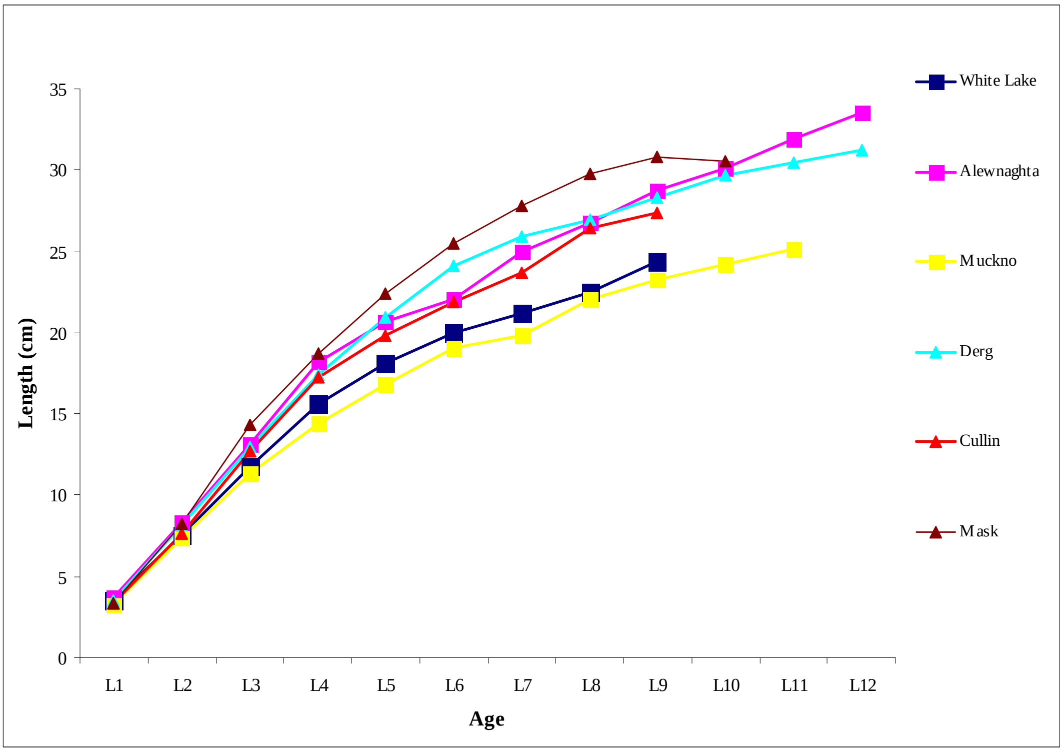

Fig. 4.40. Mean length at age of roach in lakes surveyed for WFD fish monitoring 2009 (note: circles indicate low alkalinity lakes, squares indicate moderate alkalinity lakes and triangles indicate high alkalinity lakes)

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

Brown trout from many of the high alkalinity lakes surveyed during 2009 (e.g. Lough Arrow, Lough Mask and Lough Cullin) displayed faster growth than those from the low alkalinity lakes (e.g. Dungloe Lough, Doo Lough and Lough Dan) (Fig. 4.38). Statistical analyses (One-way ANOVA) were conducted to assess the differences in mean length at age among alkalinity groups for L1 to L5 (Fig. 4.41). Mean L1, L2, L3, L4 and L5 of brown trout from low alkalinity lakes were significantly lower than moderate and high alkalinity lakes (L1 - $F_{2, 15}$=4.35, P=0.036; L2 - $F_{2, 15}$=5.55, P=0.018; L3 - $F_{2, 13}$=24.92, P<0.001; L4 - $F_{2, 10}$=28.42, P<0.001; L5 - $F_{2, 7}$=22.21, P=0.003).

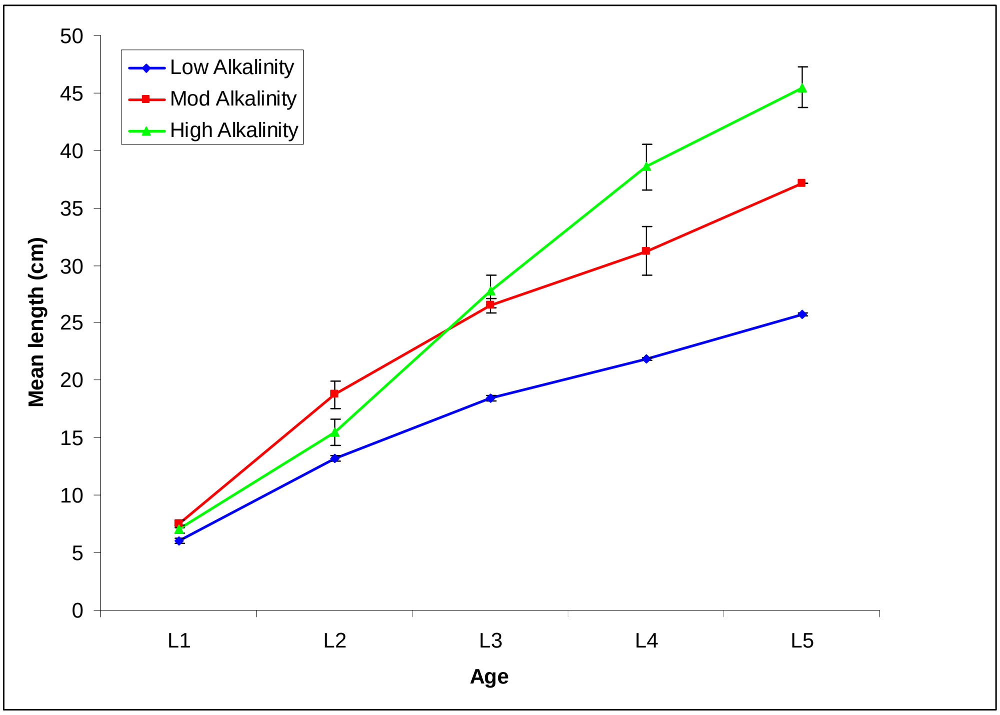

Fig 4.41. Mean (±SE) length at age of brown trout lakes surveyed for WFD fish monitoring 2009

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 during 2009, from eleven lakes (Table 4.3). Trout from Lough Muckanagh, Dungloe Lough, Doo Lough, Lough Nasnahida and Lough Cullaun 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
Anure	Kindrum	Sessiagh	Derg
Tay		Cullin	Arrow
Caum			Carra
Dan			Mask

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

Both perch and roach were only recorded in moderate and high alkalinity lakes. Figures 4.42 and 4.43 below indicate that the mean length at age is greater in high alkalinity lakes than in moderate alkalinity lakes. However, the only statistically significant differences were in perch L1 (Mann-Whitney U test, Z=2.38, p=0.14) and perch L2 (Mann-Whitney U test, Z=2.41, p=0.009). 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.

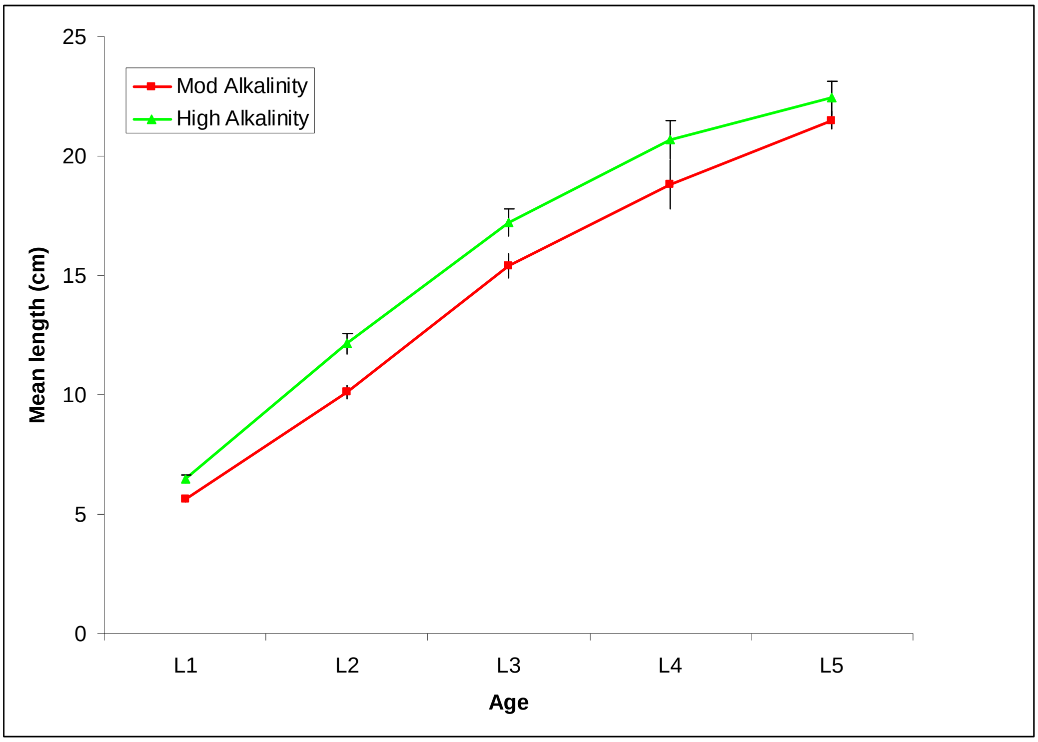

Fig 4.42. Mean (±SE) length at age of perch lakes surveyed for WFD fish monitoring 2009

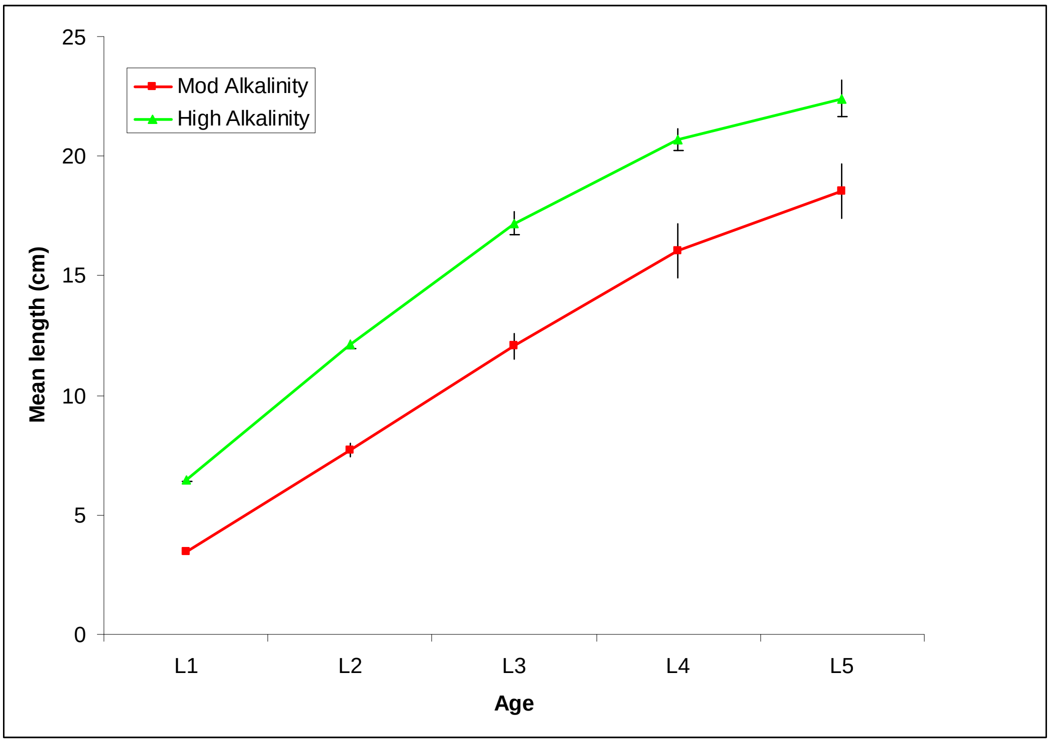

Fig 4.43. Mean (±SE) length at age of roach lakes surveyed for WFD fish monitoring 2009

4.1.5 Ecological status - Classification of lakes using the Fish in Lakes (FIL) tool

An essential step in the WFD monitoring process is the classification of the 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 (FIL) ecological classification tool 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 (Kelly *et. al.*, 2008b). All 23 lakes surveyed in 2009 were assigned a draft ecological status class using the FIL classification tool, together with expert opinion; two were classified as High, eight were classified as Good, 12 were classified as Moderate and one was classified as Poor ecological status (Table 4.4, Figure 4.44). The geographical variation in ecological status reflects the general distribution patterns of individual fish species, particularly brown trout and char. The NWIRBD, the SWRBD and the ERBD are dominated by lakes classified as High or Good ecological status, with a gradual progression to Moderate, Poor and Bad ecological status lakes as we move through the SHIRBD and NBIRBD. This reflects the change in fish communities from upland lakes with little human disturbance (mainly salmonids) to the fish communities associated with lowland lakes subject to more intensive anthropogenic pressures (mainly percids and cyprinids). The classification of each lake, based on total phosphorous (TP) (1 = low impact (oligotrophic), 5 = high impact (hypertrophic) and using the FIL classification tool, is summarized in Table 4.4.

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

Lake	Typology	Fish community type	Impact Class (TP mean)	Ecological status (FIL Tool + Expert Opinion)
Anure	2	Salmonids	2	High
Doo	4	Salmonids	2	High
Carra	10	Salmonids	1	Good
Sessiagh	7	Salmonids	2	Good
Kindrum	8	Salmonids	2	Good
Dungloe	2	Salmonids	2	Good
Nasnahida	1	Salmonids	2	Good
Dan	4	Salmonids	2	Good
Tay	3	Salmonids	2	Good
Caum	5	Salmonids	2	Good
Mask	12	Salmonids	1	Moderate
Derg	12	Salmonids	2	Moderate
Arrow	12	Salmonids	2	Moderate
Cullin	10	Salmonids	2	Moderate
Alewnaghta	6	Perch	2	Moderate
Cullaun	11	Salmonids	2	Moderate
White	6	Perch	4	Moderate
Dromore	11	Perch	2	Moderate
Inchicronan	10	Perch	2	Moderate
Muckanagh	10	Salmonids	2	Moderate
Gur	10	Rudd	2	Moderate
Bunny	10	Perch	2	Moderate
Muckno	1	Perch	3	Poor

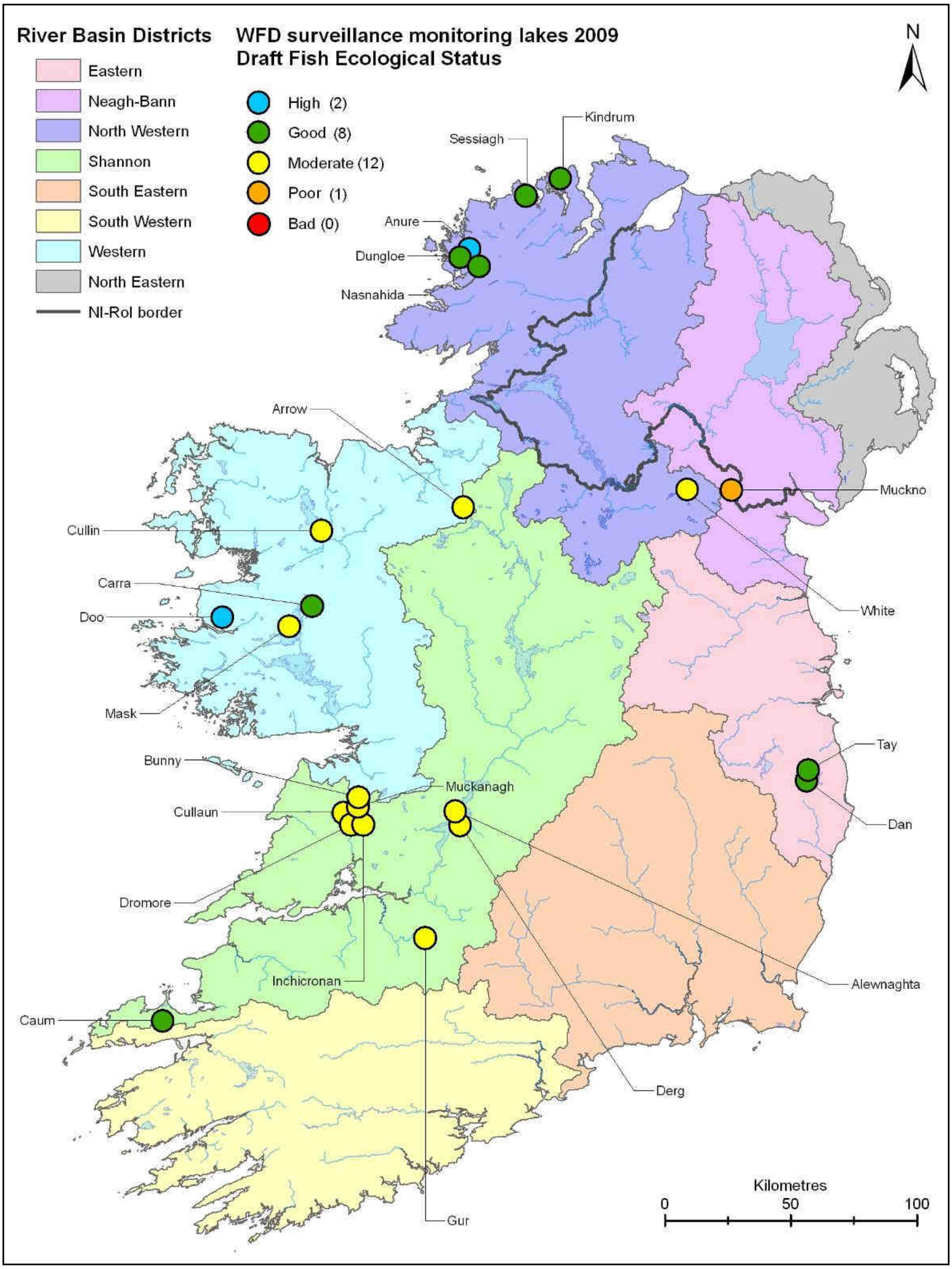

Fig. 4.44. Classification of lakes surveyed in 2009 using the Fish in Lakes tool

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 52 river sites during the project 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 52 river sites surveyed during 2009

	Scientific name	Common name	Number of river sites	% river sites
	NATIVE SPECIES			
1	*Salmo salar* (L.)	Salmon	41	79
2	*Salmo trutta* (L.)	Brown trout	50	96
3	*Salmo trutta* (L.)	Sea trout*	3	6
4	*Gasterosteus aculeatus* (L.)	Three-spined stickleback	19	37
5	*Pungitius pungitius* (L.)	Nine-spined stickleback	2	4
6		Juvenile lamprey	14	27
7	*Platichthys flesus* (Duncker)	Flounder	4	8
8	*Anguilla anguilla* (L.)	Eel	43	83
	NON NATIVE SPECIES (influencing ecology)			
9	*Esox lucius* (L.)	Pike	9	17
10	*Rutilus rutilus* (L.)	Roach	9	17
11	*Perca fluviatilis* (L.)	Perch	11	21
12	*Abramis brama* (L.)	Bream	1	2
13	*Phoxinus phoxinus* (L.)	Minnow	15	29
14	*Barbatula barbatula* (L.)	Stoneloach	28	54
15	*Leuciscus leuciscus* (L.)	Dace	4	8
	NON NATIVE SPECIES (generally not influencing ecology)			
16	*Gobio gobio* (L.)	Gudgeon	9	17
	Hybrids			
	Roach x bream hybrid	Roach x bream hybrid	9	17

*sea trout are included as a separate “variety” of trout

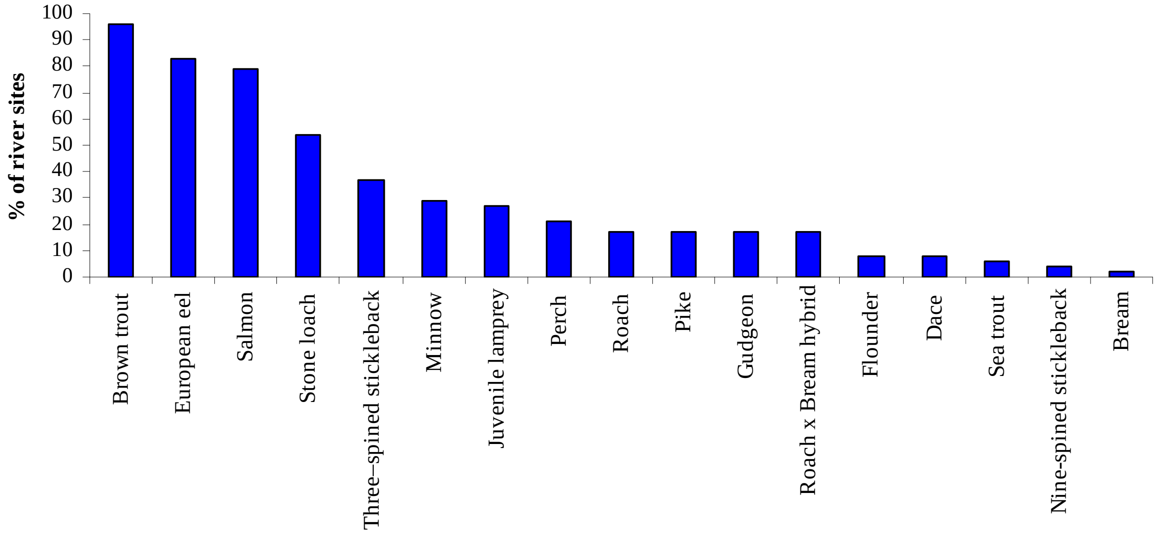

Fig. 4.45. Percentage of sites where each fish species was recorded (total of 52 river sites surveyed) during WFD surveillance monitoring 2009

Overall, a total of 16 fish species (sea trout are included as a separate variety of trout) and one type of hybrid were recorded in the 52 river sites surveyed during 2009. Brown trout were the most widespread species occurring in 96% of the sites surveyed, followed by eels (83%), salmon (79%), stone loach (54%), 3-spined stickleback (37%), minnow (29%), juvenile lamprey (27%), perch (21%), roach (17%), pike (17%), gudgeon (17%) and roach × bream hybrids (17%). Flounder, dace, nine-spined stickleback and bream 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 (Feorish River stream in the SHIRBD) to a maximum of eleven species at one site (River Barrow in the SERBD) (Table 4.6 and Figs. 4.46 and 4.47). Native species were present at all sites surveyed except for the Feorish River in the SHIRBD, where only a single pike was recorded. Only 16 out of a total of 52 sites contained exclusively native species. The maximum number of native species captured in any site was five and this was recorded in a number of river sites, including the Athboy, Bandon, Burren, Creegh, Greese, Nanny (Meath) and Owvane (Limerick) (Table 4.6). Group 2 species (non native species influencing ecology) were present at 16 sites, and the maximum number of non-native species recorded at any one site was eight species in the River Barrow (excluding roach × bream hybrids that were also recorded in this river). Only one Group 3 species (gudgeon) was present in the river sites surveyed, being recorded at eight sites.

Table 4.6. Species richness at each river site surveyed for WFD fish monitoring 2009

Site	RBD	Species richness	No. native species (Group 1)	No. non-native species (Group 2)	No. non-native species (Group 3)
Bank-based electric-fishing					
Blackwater (Kells)	ERBD	8	3	4	1
Nanny (Meath)	ERBD	7	5	2	0
Athboy	ERBD	6	5	1	0
White (Louth)	NBIRBD	6	4	2	0
Burren	SERBD	6	5	1	0
Greese	SERBD	6	5	1	0
Moyree	SHIRBD	6	4	2	0
Argideen	SWRBD	6	4	2	0
Owendalulleegh	WRBD	6	3	2	1
Dargle	ERBD	5	5	0	0
Bilboa	SHIRBD	5	4	1	0
Broadford	SHIRBD	5	4	1	0
Dead	SHIRBD	5	4	1	0
Owvane (Limerick)	SHIRBD	5	5	0	0
Owenbrin	WRBD	5	2	3	0
Unshin	WRBD	5	2	3	0
Glencree	ERBD	4	3	1	0
Tully Stream	SERBD	4	3	1	0
Ballyfinboy	SHIRBD	4	3	1	0
Black (Shrule)	WRBD	4	4	0	0
Glenealo	ERBD	3	3	0	0
Clady (Donegal)	NWIRBD	3	3	0	0
Glendine (Clare)	SHIRBD	3	3	0	0
Newport	SHIRBD	3	3	0	0
Gowlan	WRBD	3	3	0	0
Big (Louth)	NBIRBD	2	2	0	0
Caher	SHIRBD	2	2	0	0
Owveg (Kerry)	SHIRBD	2	2	0	0
Tyshe	SHIRBD	2	2	0	0
Funshion	SWRBD	2	2	0	0
Dunneill	WRBD	2	2	0	0
Boat-based electric-fishing					
Barrow	SERBD	12	3	7	1
Finn (Monaghan)	NWIRBD	9	4	4	1
Dee	NBIRBD	8	4	3	1
Blackwater (Killavullen Br.)	SWRBD	8	3	4	1
Liffey (Lucan)	ERBD	7	4	3	0
Boyne (Boyne Br.)	ERBD	6	4	2	0
Erne (Bellahillan Br.)	NWIRBD	6	2	3	1
Bandon	SWRBD	6	5	1	0
Creegh	SHIRBD	5	5	0	0

Table 4.6 contd. Species richness at each river site surveyed for WFD fish monitoring 2009

Site	RBD	Species richness	No. native species (Group 1)	No. non-native species (Group 2)	No. non-native species (Group 3)
Fergus	SHIRBD	5	3	2	0
Nenagh	SHIRBD	5	3	2	0
Awbeg (Buttevant)	SWRBD	5	3	2	0
Blackwater (Nohaval Br.)	SWRBD	5	3	2	0
Bride	SWRBD	5	4	1	0
Nanny (Tuam)	WRBD	5	2	3	0
Dinin	SERBD	4	3	1	0
King's (Kilkenny)	SERBD	4	4	0	0
Slaney	SERBD	4	3	1	0
Shannon (Ballyleague Br.)	SHIRBD	4	1	3	0
Liffey (Ballyward Br.)	ERBD	3	1	2	0
Feorish (Ballyfarnon)	SHIRBD	1	0	1	0

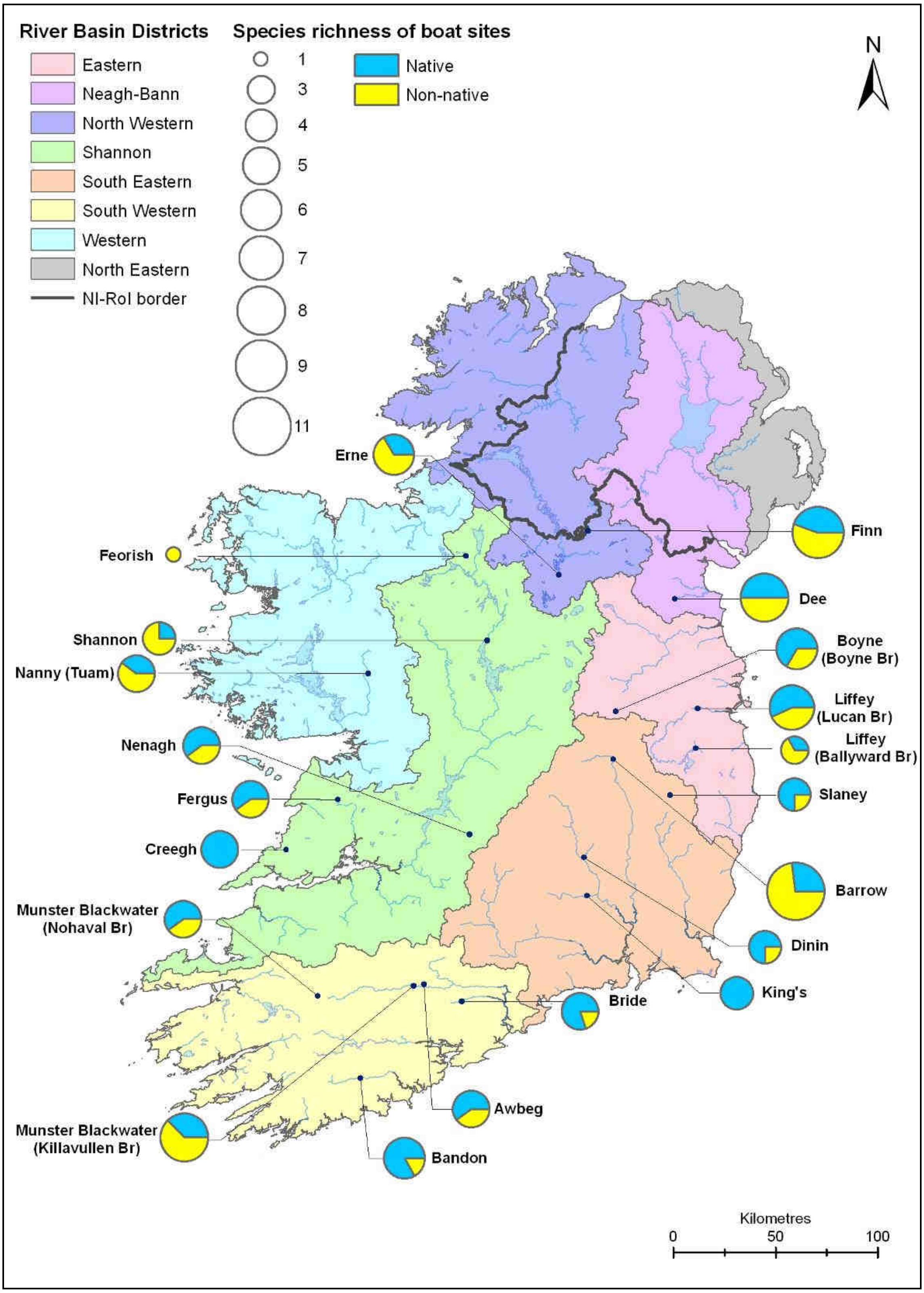

Fig. 4.46. Fish species richness at boat river sites, July to October 2009

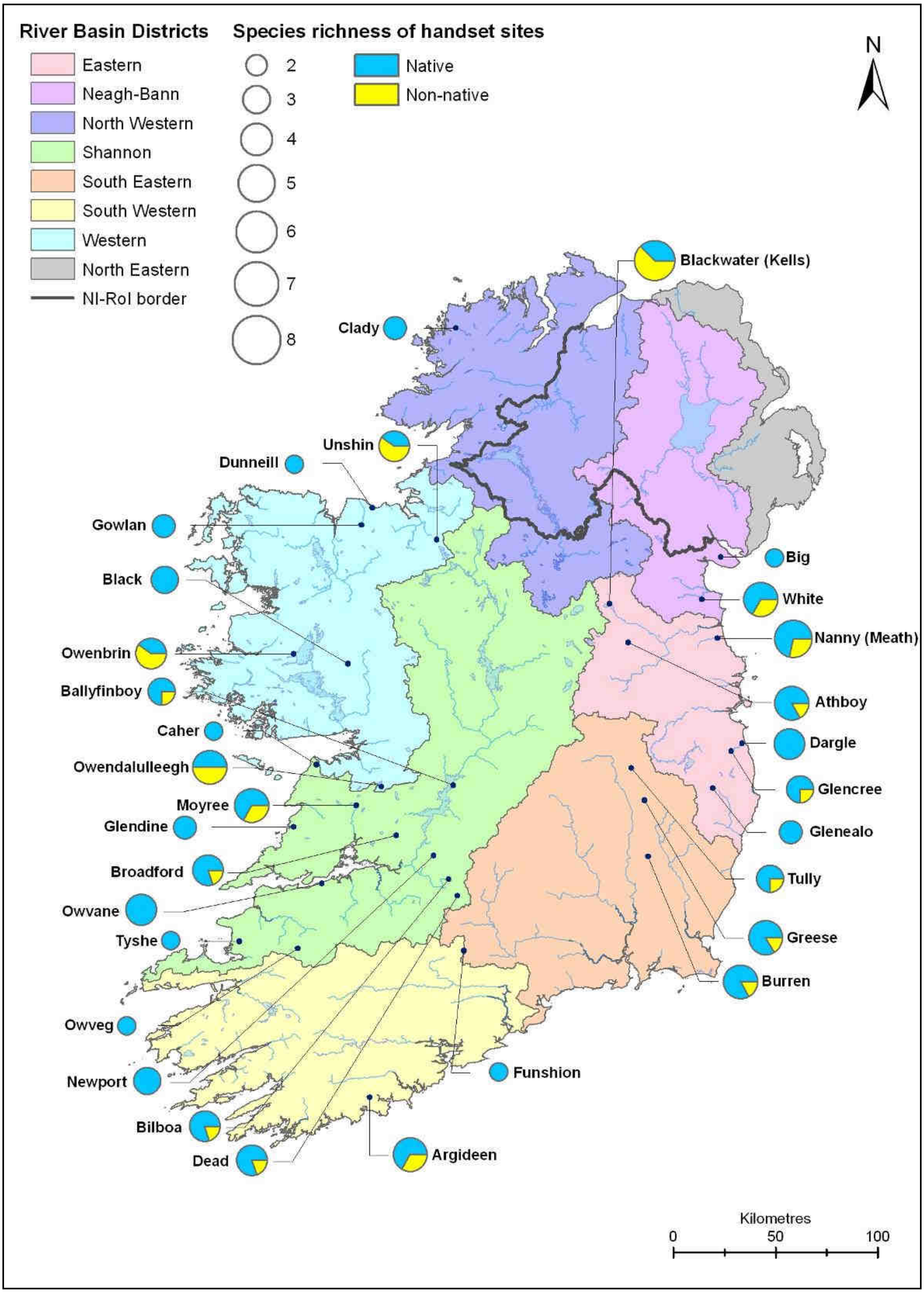

Fig. 4.47. Fish species richness at handset river sites, July to October 2009

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 52 river sites surveyed during 2009. 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 widely distributed among sites surveyed in 2009 (Fig. 4.48 to Fig. 4.51), only being absent from four sites; the Tyshe River in the SWRBD, the Feorish River and River Shannon in the ShIRBD and the River Erne in the NWIRBD. Brown trout fry (0+) were present in 40 sites (Fig. 4.48 and Fig. 4.49), while older fish (1+ and older) were encountered in 47 sites (Fig. 4.50 and Fig. 4.51). Brown trout fry (0+) densities were consistently higher in the wadeable streams than in the channels where boats were used to carry out the survey. In the boat sampled rivers, the highest density of fry (0.01 fish/m^2) were captured in the Nenagh River within the ShIRBD and the highest density of 1+ and older fish were recorded in the Boyne River (Boyne Br) (ERBD) (0.07 fish/m^2). In the wadeable streams, the highest densities of fry (0.18 fish/m^2) and 1+ and older fish (0.30 fish/m^2) were recorded in the Caher River (ShIRBD) and Big River (NBIRBD) respectively.

Sea trout, as expected, were only recorded in sites close to the coast and in rivers that allow upstream access (Fig. 4.52 and Fig. 4.53). They were only captured in three of the rivers surveyed; the Dargle River (ERBD), Gowlan River (WRBD) and River Bride (SWRBD). The greatest density of sea trout (although still relatively low when compared with other species) was recorded in the Dargle River (<0.01 fish/m^2).

Salmon were also widely distributed throughout the country, being present in 41 sites. Salmon fry (0+) were captured in 35 sites (Fig. 4.54 and Fig. 4.55), while older salmon (1+ & older) were recorded in 39 sites (Fig. 4.56 and Fig. 4.57). In a similar trend to that of the brown trout, salmon fry (0+) densities were generally higher in the streams surveyed by wading than in channels sampled with boats. Salmon were also present in greater densities in sites closest to the west coast. For the sites sampled using boats, the highest densities of fry (<0.01 fish/m^2) were recorded in the River Liffey at Lucan within the ERBD, whilst the highest densities of 0+ and older salmon were captured in the Slaney (0.04 fish/m^2). Amongst the wadeable streams, the highest densities of both fry (0.35 fish/m^2) and 0+ and older fish (0.23 fish/m^2) were recorded in the Bilboa River (ShIRBD).

Eels were present in 43 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 (0.28 fish/m^2) was recorded within the ShIRBD, in the Tyshe River.

Flounder were recorded in four sites; the River Nanny (Meath) (ERBD), the Owvane River (ShIRBD), the Dargle River (ERBD) and the Creegh River (ShIRBD), all of which are located close to the sea

(Fig. 4.60 and Fig. 4.61). The highest density of flounder was recorded in the Owvane River with 0.04 fish/m^2.

Three-spined stickleback were distributed throughout the country (Fig. 4.62 and Fig. 4.63) and were captured in 19 sites. Their highest density (0.1 fish/m^2) was recorded in the Tully Stream within the SERBD.

Lamprey were recorded in 14 river sites (Fig. 4.64 and Fig. 4.65), of which the Burren River within the SERBD had the highest density (0.09 fish/m^2). Stone loach were widespread throughout the whole country (Fig. 4.66 and Fig. 4.67), with the greatest density (0.19 fish/m^2) recorded in the White River. Minnow were generally more abundant in the east (Fig. 4.68 and Fig. 4.69); however their greatest density (0.4 fish/m^2) was recorded in the Owenbrin River within the WRBD.

Roach (Fig. 4.70 and Fig. 4.71) were more prevalent in deeper sites and were distributed mainly in north eastern areas, including the ERBD, NWRBD (Co. Monaghan/Cavan) and NBIRBD. The greatest density (0.22 fish/m^2) of roach was recorded in the River Blackwater (Kells). The most southerly location where roach were recorded was in the River Blackwater (Killavullen) in north Co. Cork, where two specimens were captured.

Perch were recorded in eleven sites (Fig. 4.72 and Fig. 4.73) distributed throughout the northern half of the country. In a similar trend to that in 2008 (Kelly *et al*., 2009), perch were mainly recorded in the ShIRBD; however, the highest density of perch was recorded in the Unshin River within the WRBD (0.01 fish/m^2).

Pike (Fig. 4.74 and Fig. 4.75) were captured at nine river sites during 2009. The Moyree River within the ShIRBD exhibited the highest density of pike (<0.01 fish/m^2), although this was relatively small when compared to most other species captured. Pike distribution was similar to 2008 (Kelly *et al*., 2009), where most records were within the ShIRBD and NWIRBD.

Gudgeon (Fig. 4.76 and Fig. 4.77) were again most common within the ShIRBD and in areas closely bordering it, e.g. the southern part of the NRBD and ERBD. Other locations in which gudgeon were recorded include the River Barrow within the SERBD and the Munster Blackwater (Killavullen) within the SWRBD. The highest recorded density of gudgeon (0.15 fish/m^2) was in the Broadford River within the ShIRBD.

Dace, a non-native invasive fish species, were recorded in four sites during 2009 (Fig. 4.78 and Fig. 4.79). Within the SRBD, they were recorded at two sites located very close together in the Barrow catchment - the Tully Stream where the greatest density (<0.01 fish/m^2) was recorded and the River Barrow at Pass Bridge. Further south they were present in sites on the Munster Blackwater (Killavullen) and its tributary, the Awbeg River.

A number of other fish species were only encountered in a few locations. Nine-spined stickleback were present in the Tully Stream and Burren River (SERBD), while bream and roach x bream hybrids were recorded in the River Barrow at Pass Bridge (SERBD).

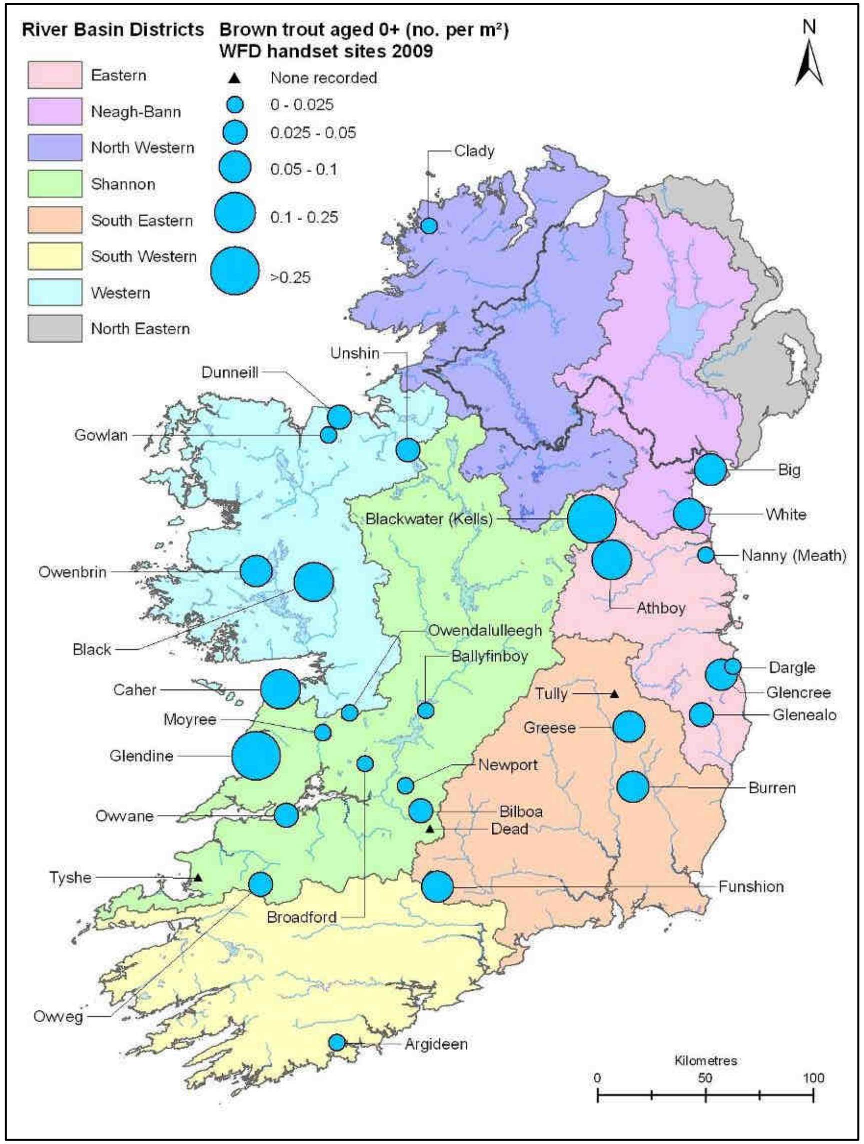

Fig. 4.48. Distribution and abundance of 0+ brown trout at river hand-set sites surveyed for WFD monitoring 2009

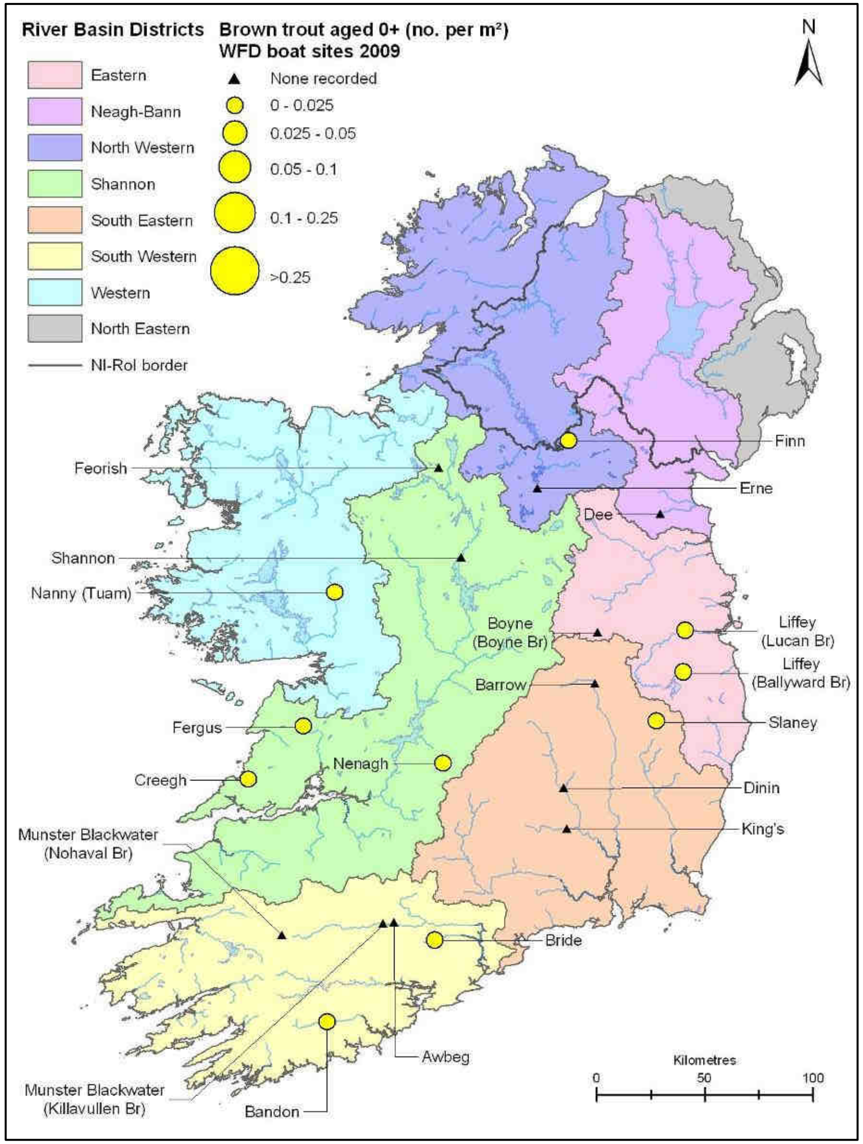

Fig. 4.49. Distribution and abundance of 0+ brown trout at river boat sites surveyed for WFD monitoring 2009

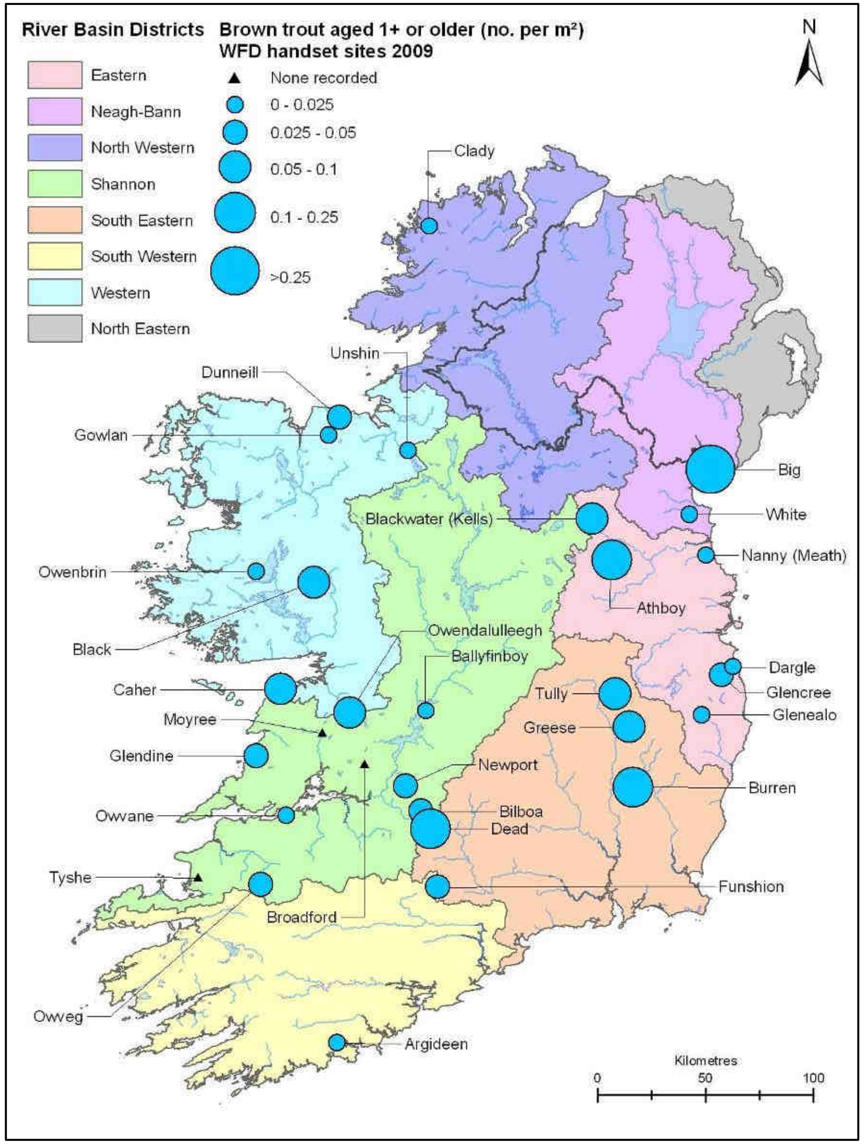

Fig. 4.50. Distribution and abundance of 1+ or older brown trout at river hand-set sites surveyed for WFD monitoring 2009

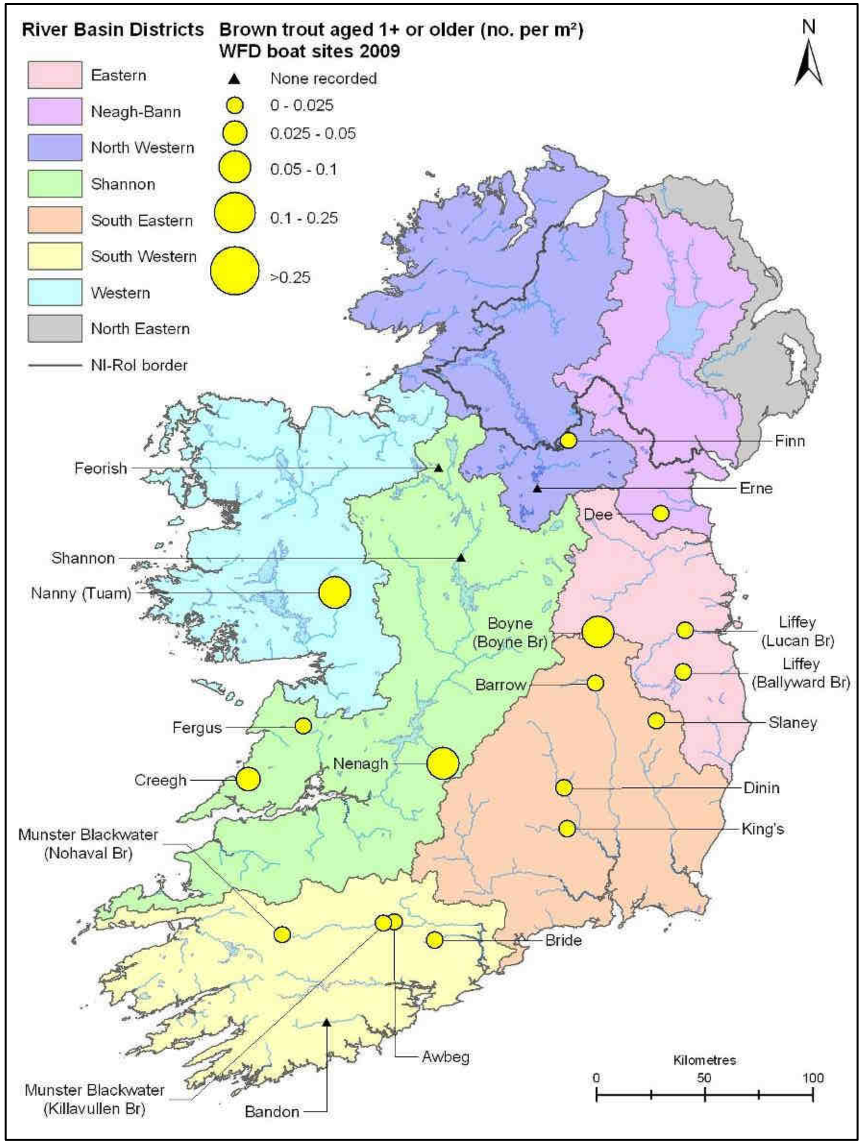

Fig. 4.51. Distribution and abundance of 1+ or older brown trout at river boat sites surveyed for WFD monitoring 2009

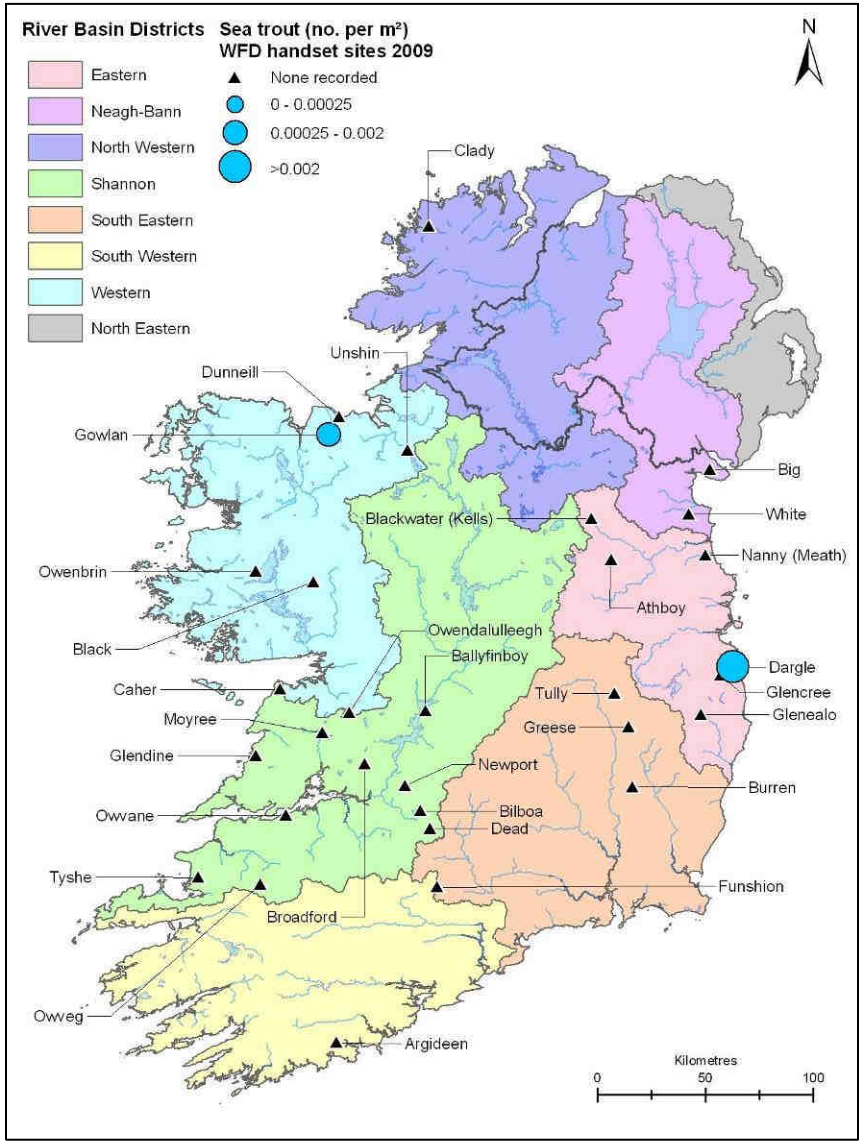

Fig. 4.52 Distribution and abundance of sea trout at river hand-set sites surveyed for WFD monitoring 2009

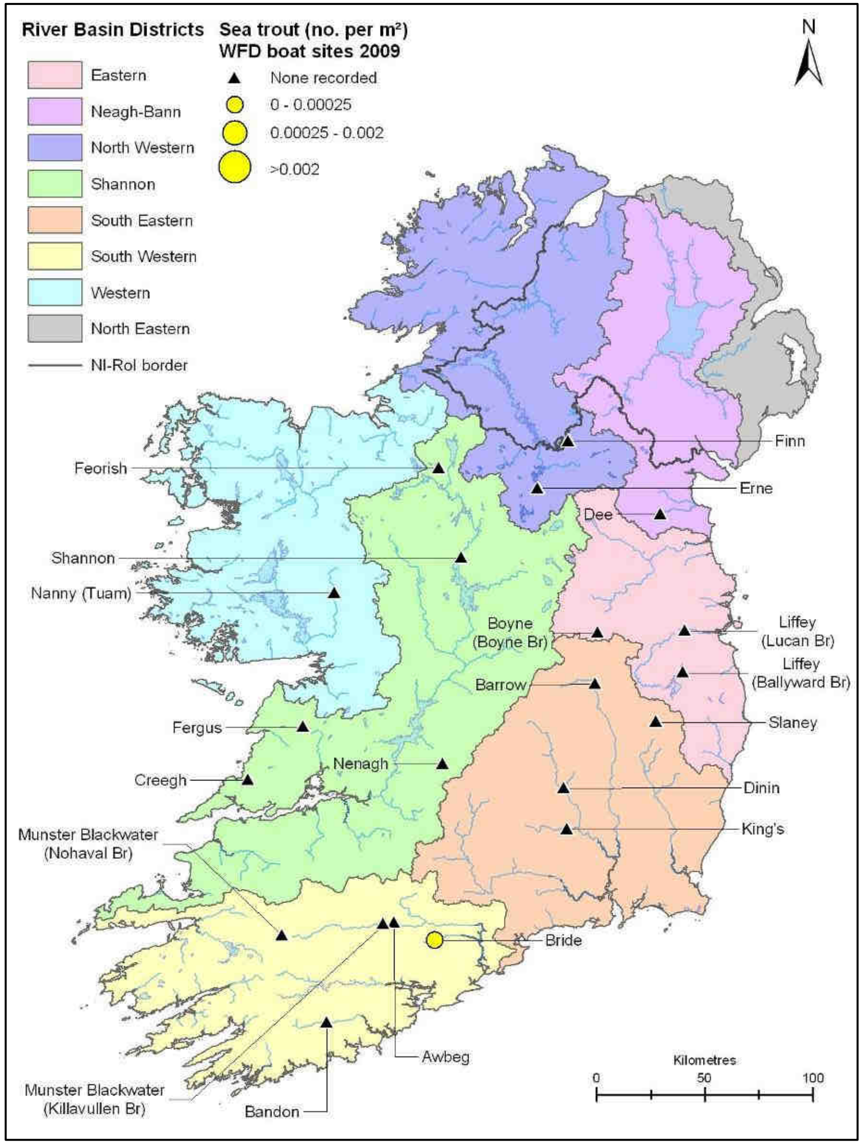

Fig. 4.53. Distribution and abundance of sea trout at river boat sites surveyed for WFD monitoring 2009

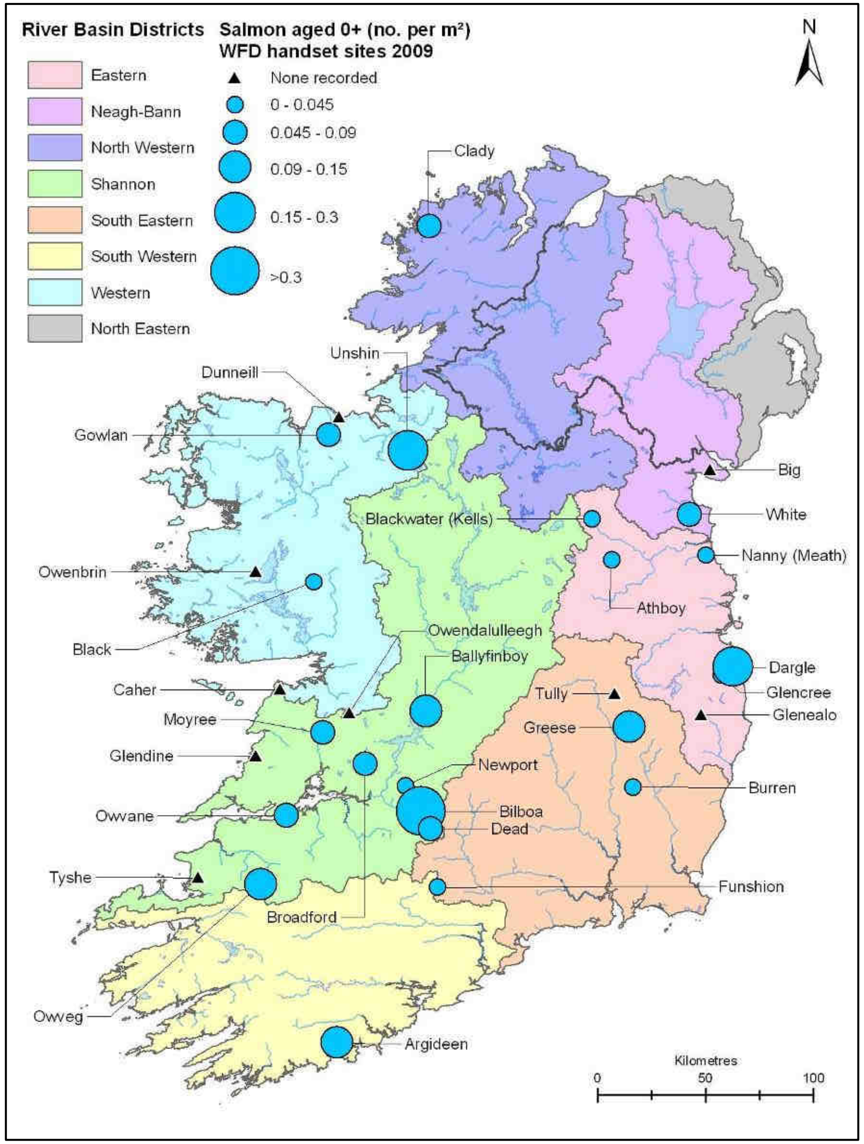

Fig. 4.54. Distribution and abundance of salmon aged 0+ at river hand-set sites surveyed for WFD monitoring 2009

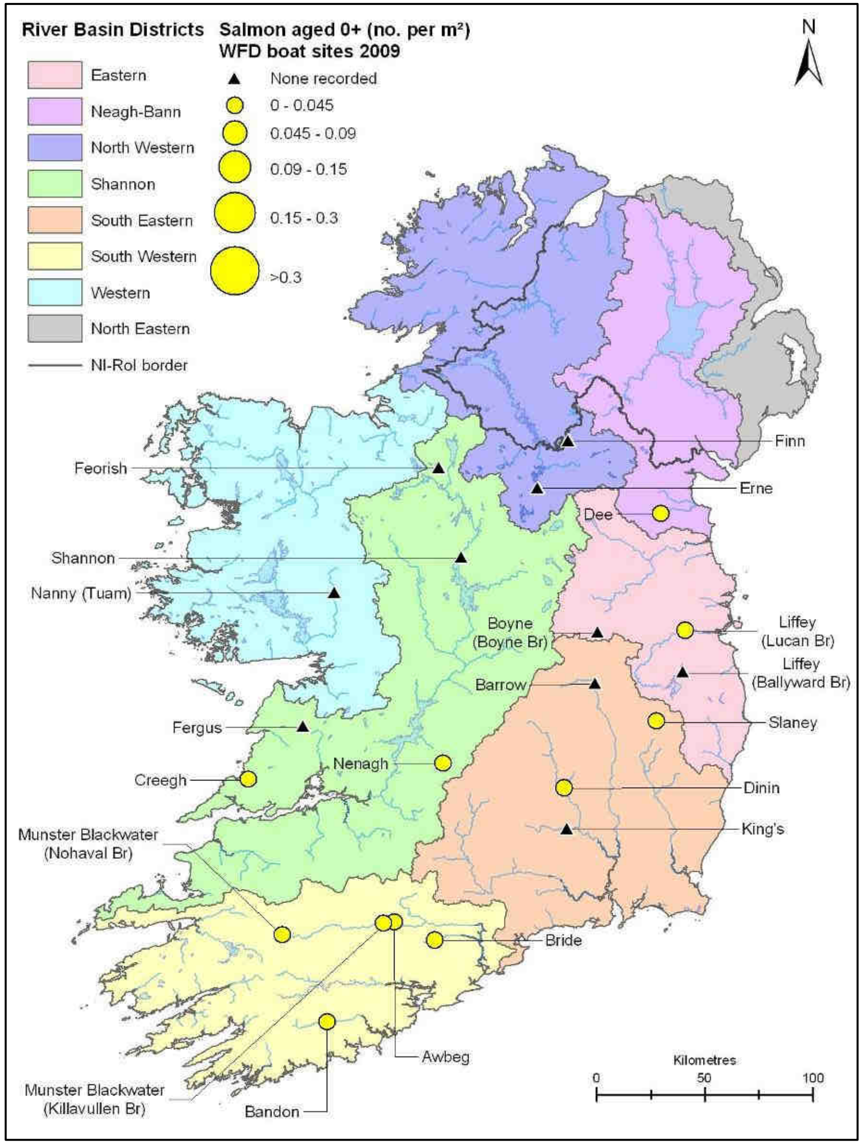

Fig. 4.55. Distribution and abundance of salmon aged 0+ at river boat sites surveyed for WFD monitoring 2009

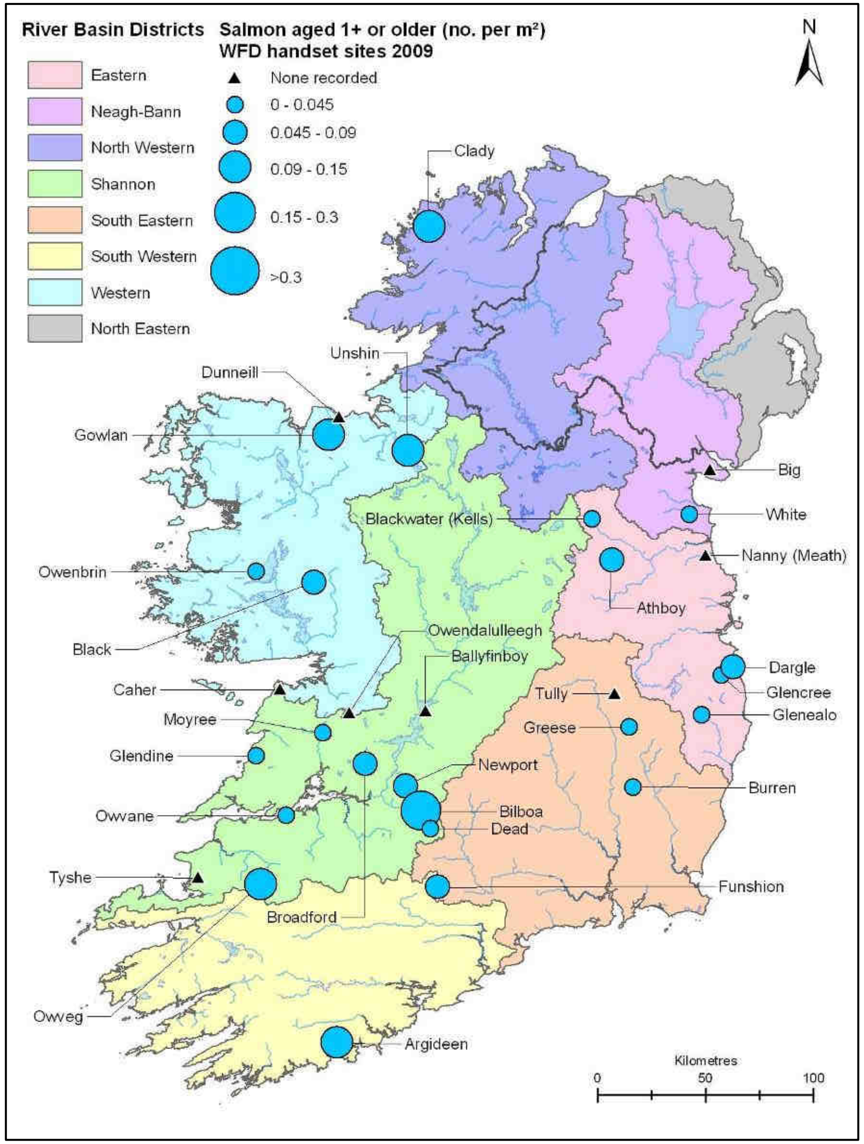

Fig. 4.56. Distribution and abundance of salmon aged 1+ or older at river hand-set sites surveyed for WFD monitoring 2009

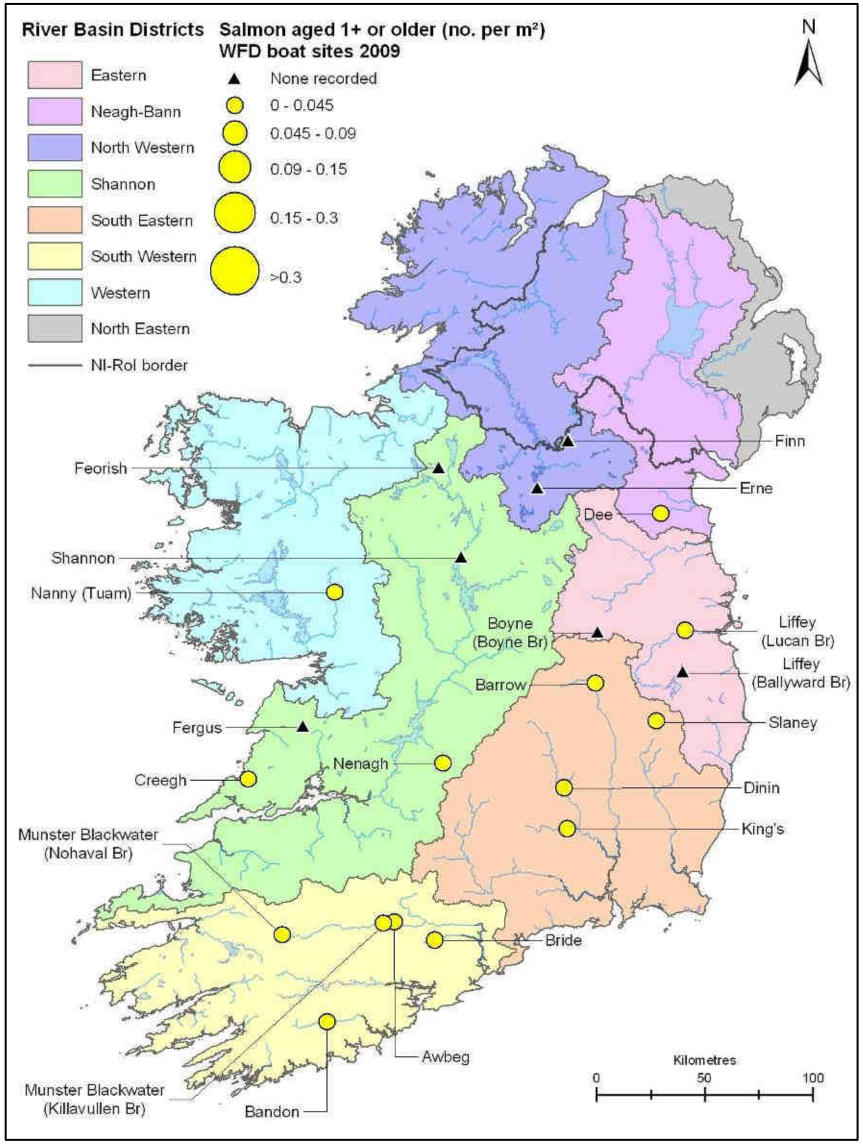

Fig. 4.57. Distribution and abundance of salmon aged 1+ or older at river boat sites surveyed for WFD monitoring 2009

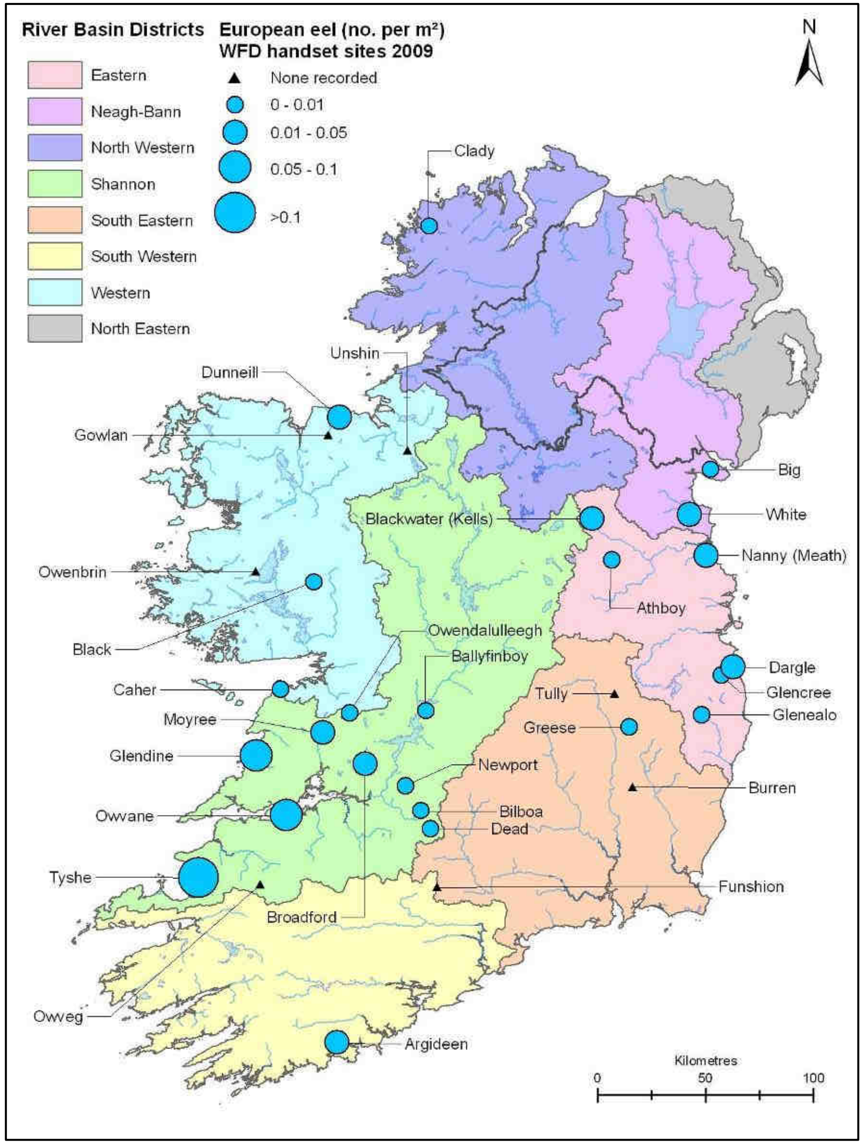

Fig. 4.58. Distribution and abundance of European eel at river hand-set sites surveyed for WFD monitoring 2009

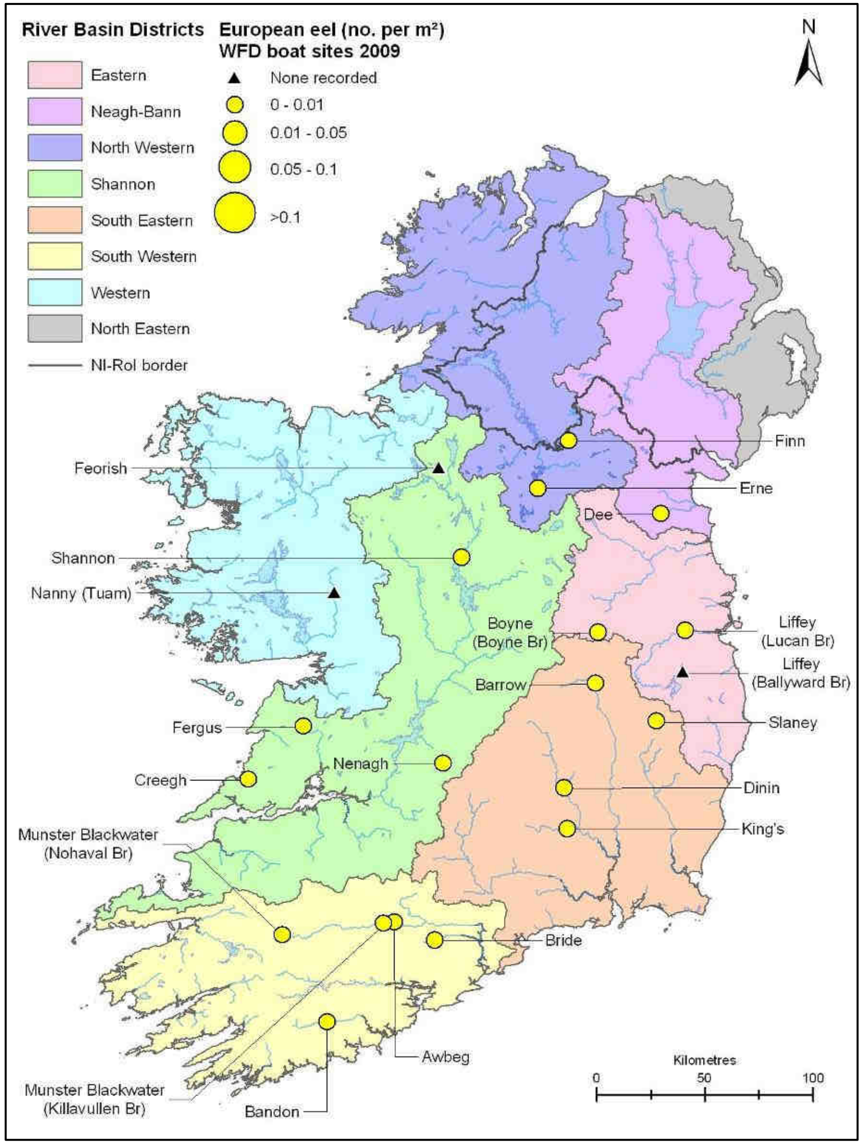

Fig. 4.59. Distribution and abundance of European eel at river boat sites surveyed for WFD monitoring 2009

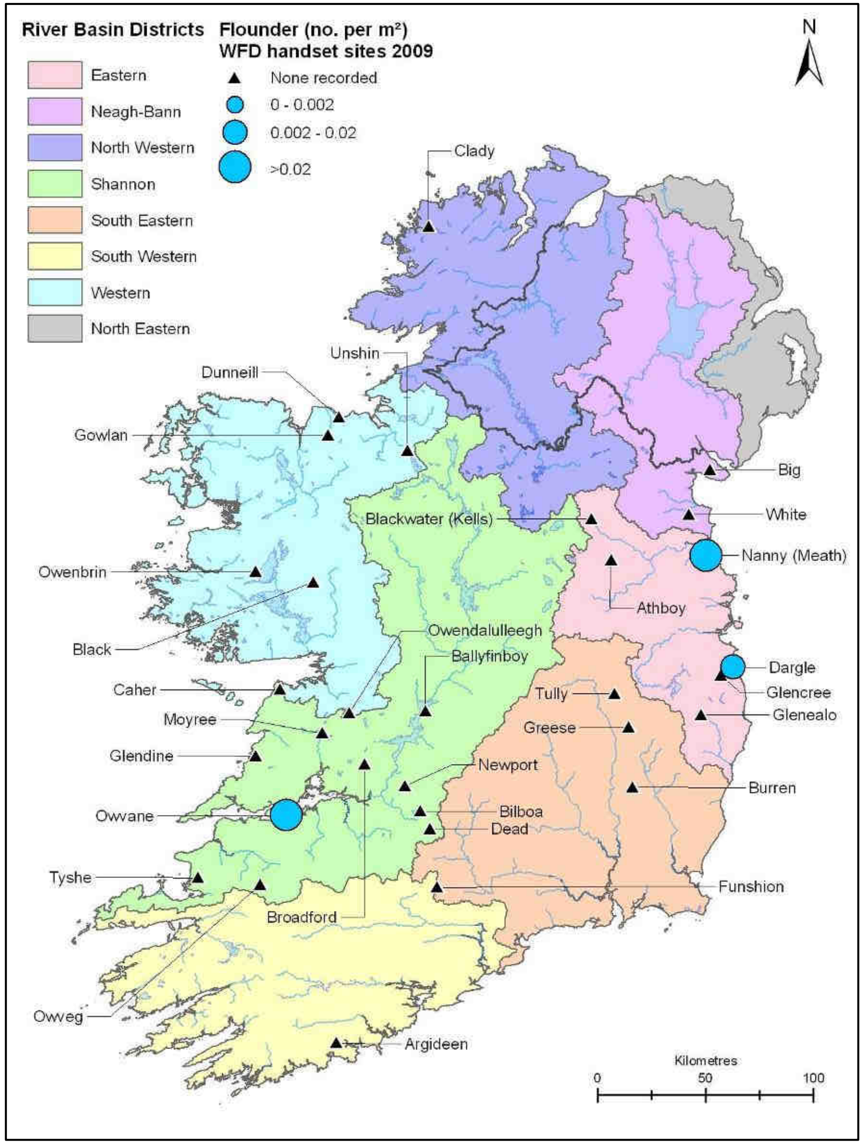

Fig. 4.60. Distribution and abundance of flounder at river hand-set sites surveyed for WFD monitoring 2009

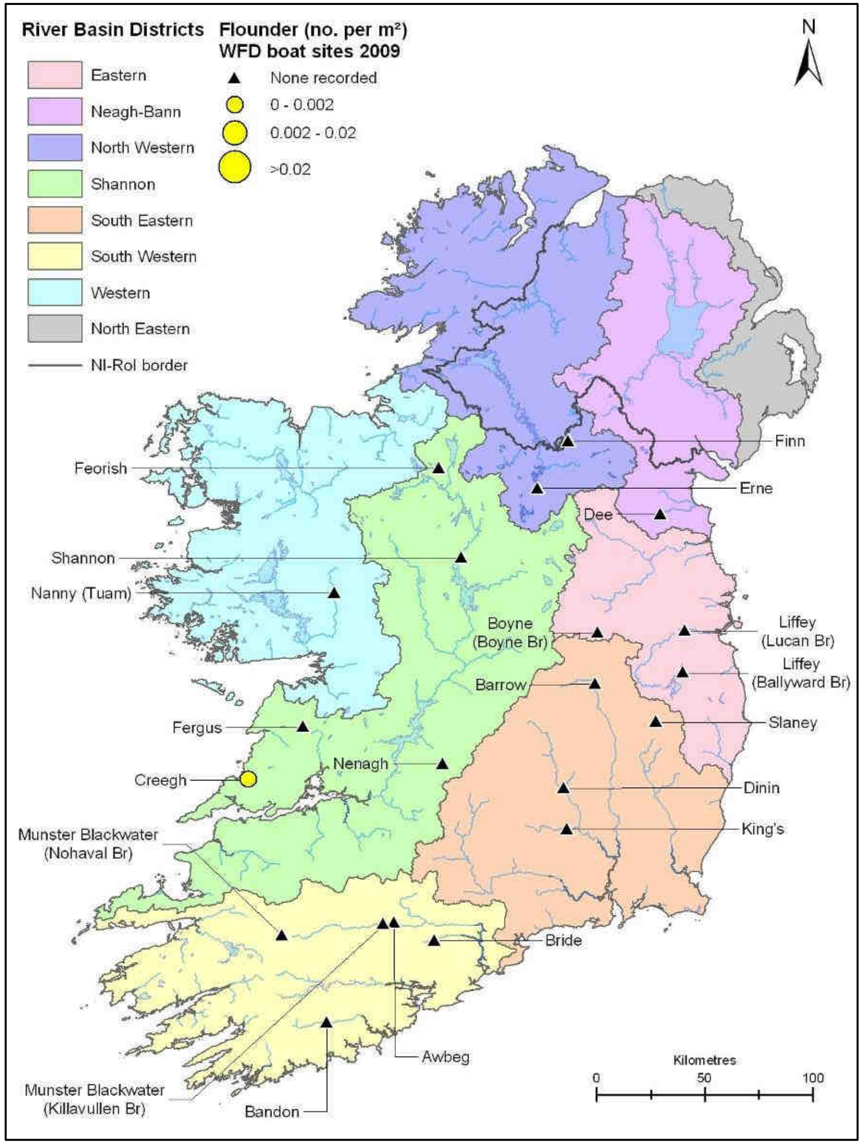

Fig. 4.61. Distribution and abundance of flounder at river boat sites surveyed for WFD monitoring 2009

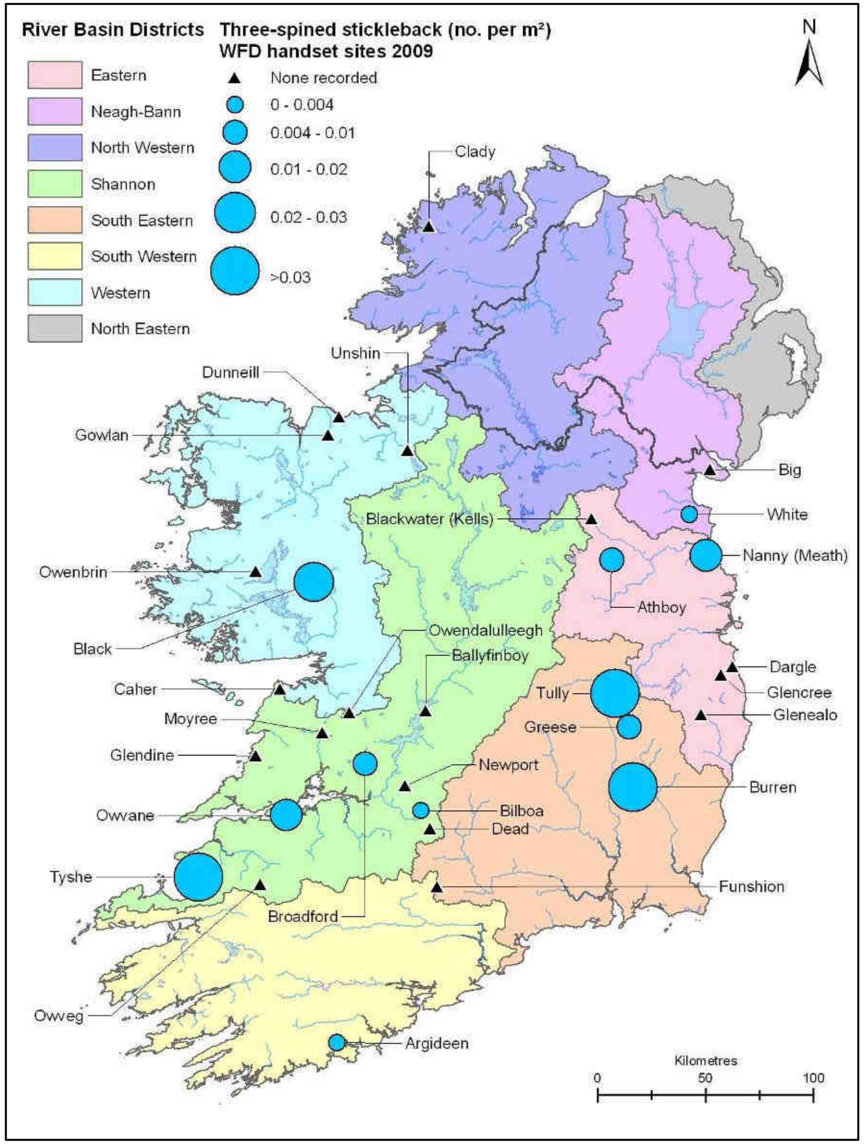

Fig. 4.62. Distribution and abundance of three-spined stickleback at river hand-set sites surveyed for WFD monitoring 2009

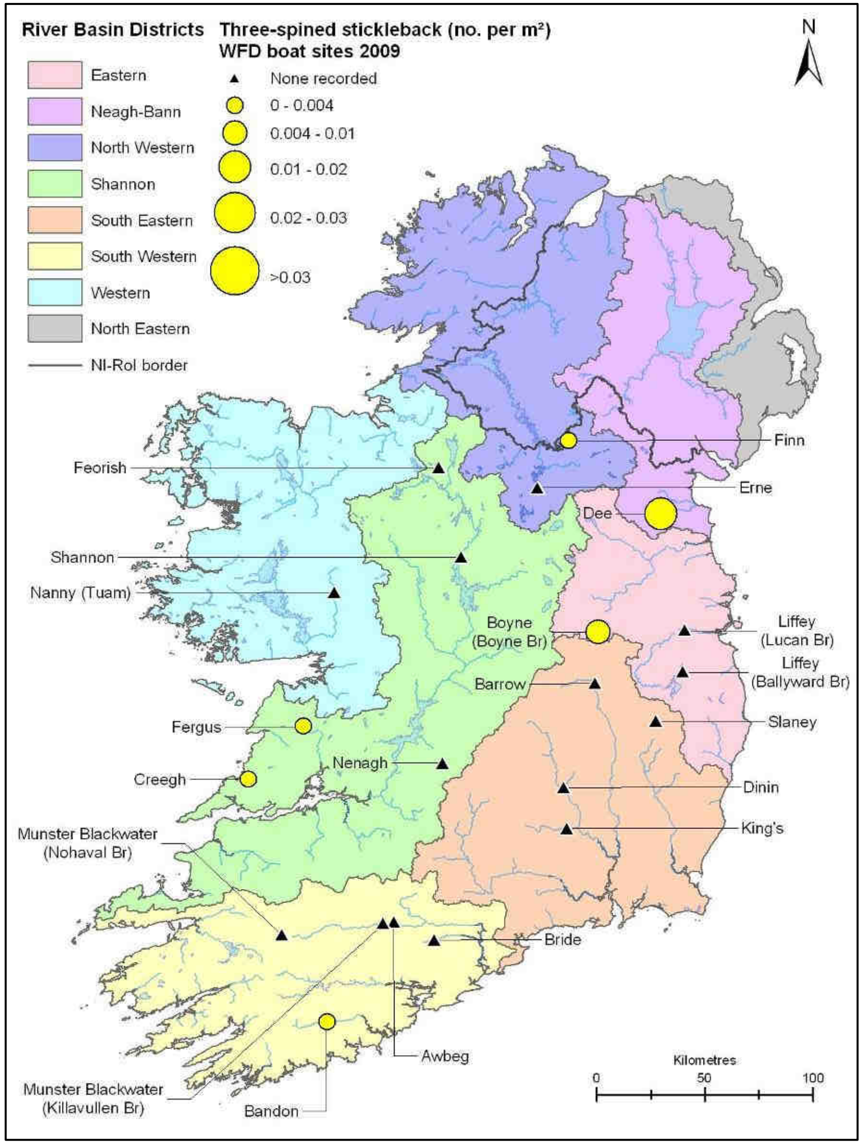

Fig. 4.63. Distribution and abundance of three-spined stickleback at river boat sites surveyed for WFD monitoring 2009

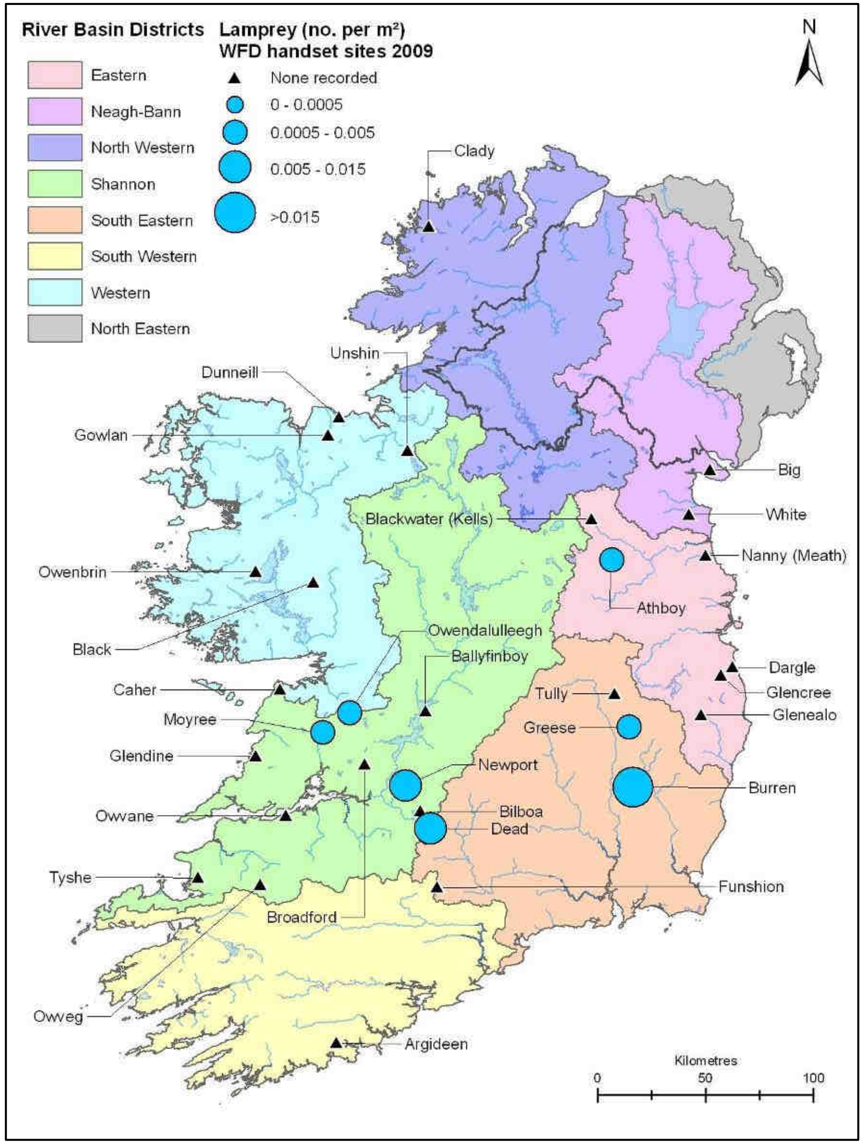

Fig. 4.64. Distribution and abundance of lamprey at river hand-set sites surveyed for WFD monitoring 2009

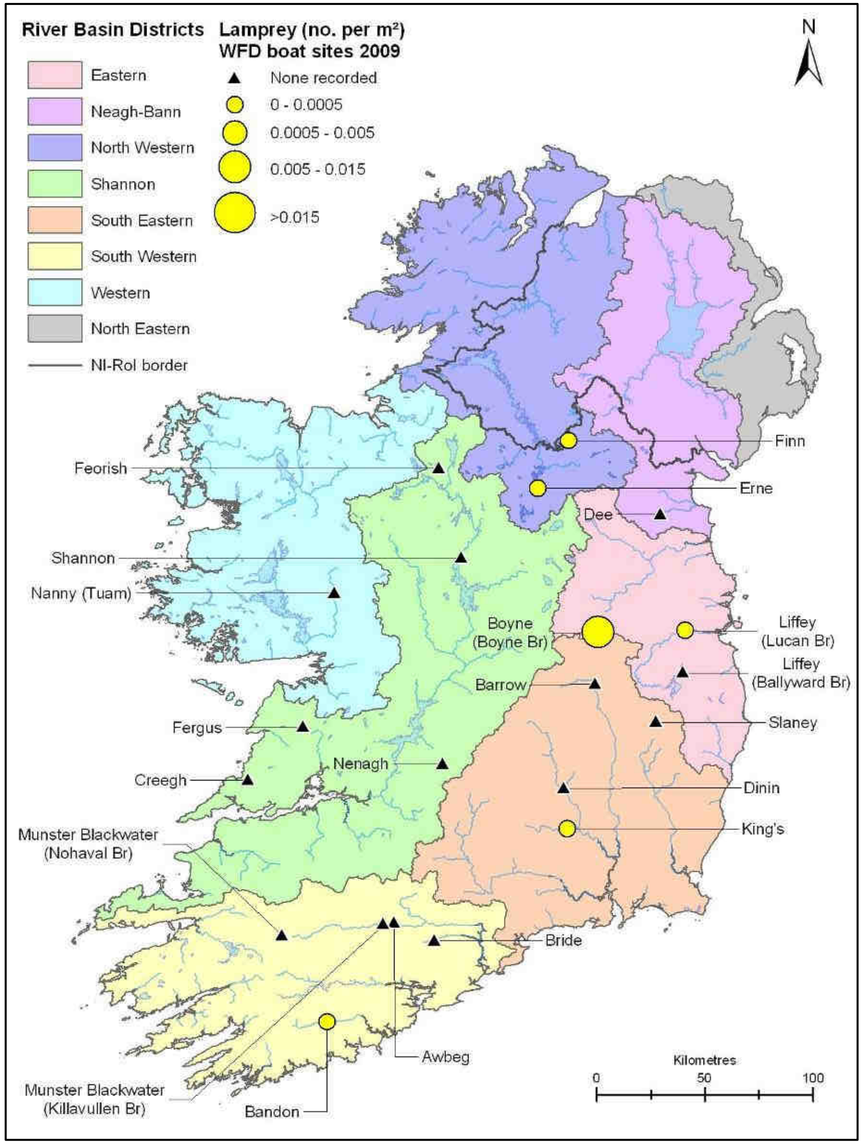

Fig. 4.65. Distribution and abundance of lamprey at river boat sites surveyed for WFD monitoring 2009

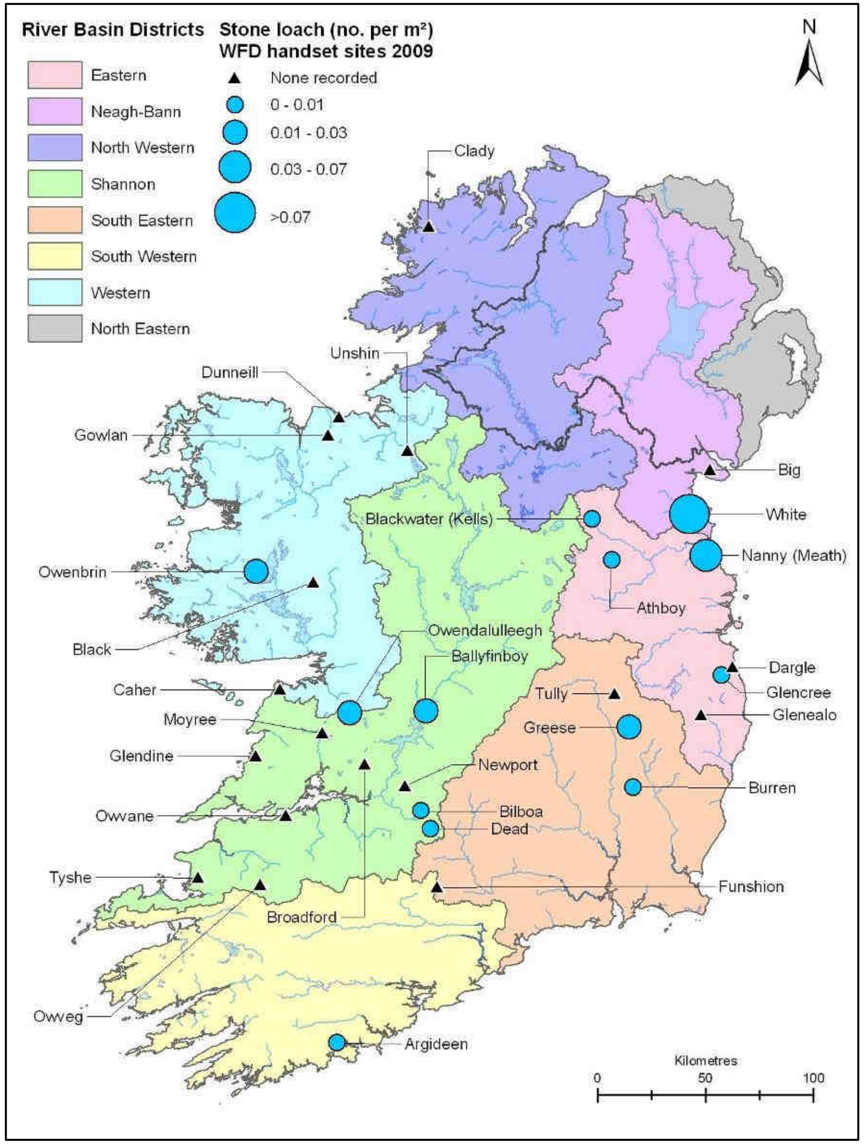

Fig. 4.66. Distribution and abundance of stone loach at river hand-set sites surveyed for WFD monitoring 2009

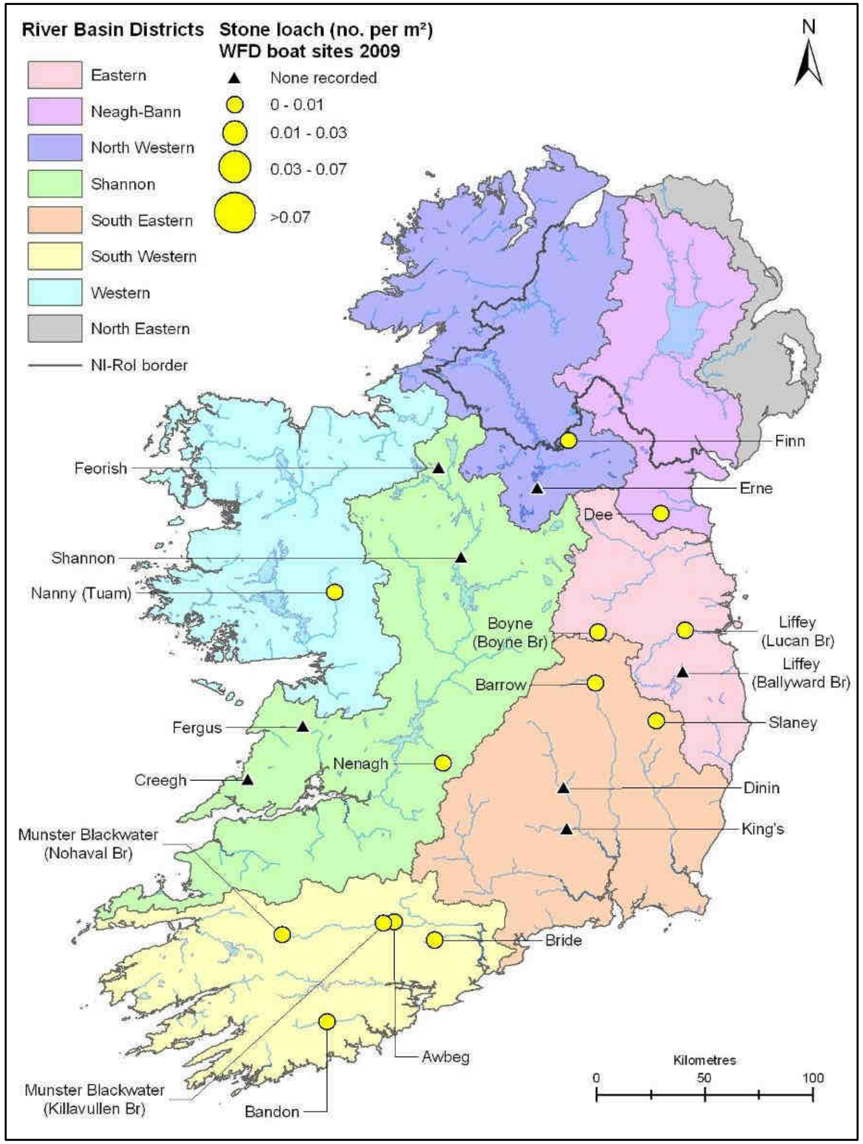

Fig. 4.67. Distribution and abundance of stone loach at river boat sites surveyed for WFD monitoring 2009

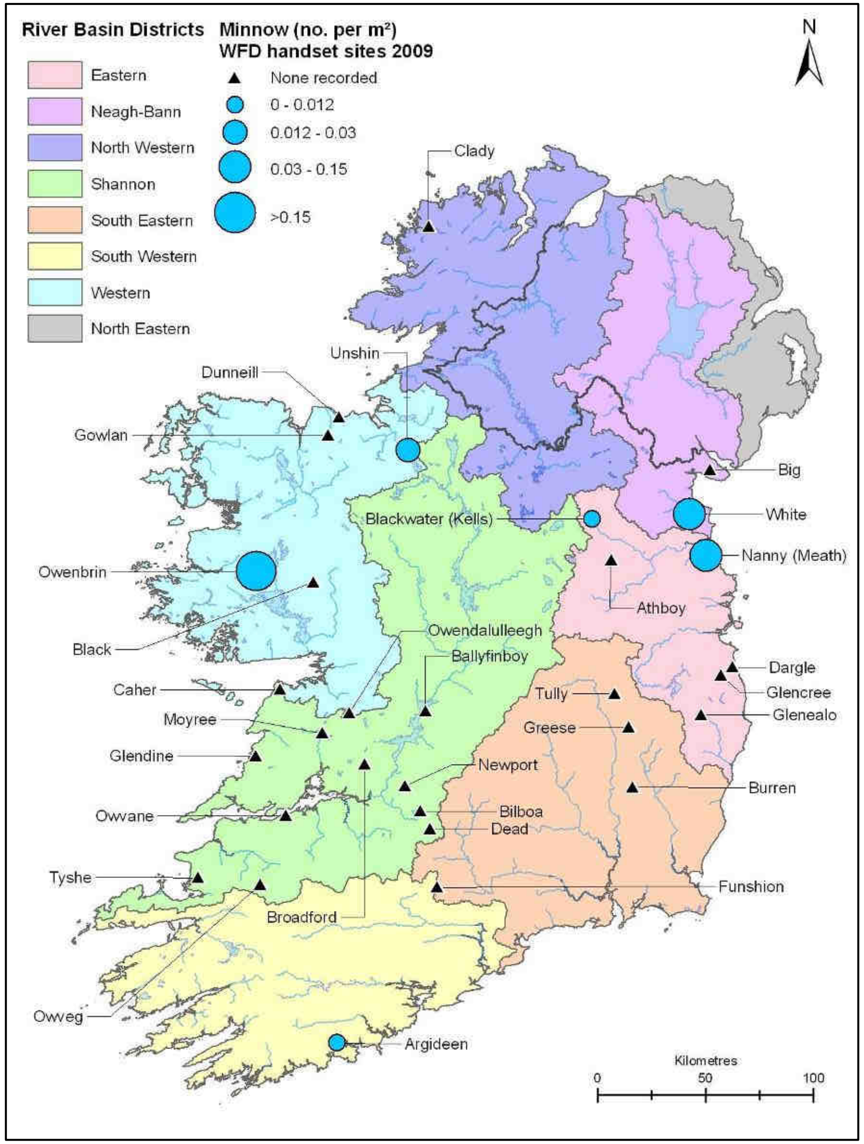

Fig. 4.68. Distribution and abundance of minnow at river hand-set sites surveyed for WFD monitoring 2009

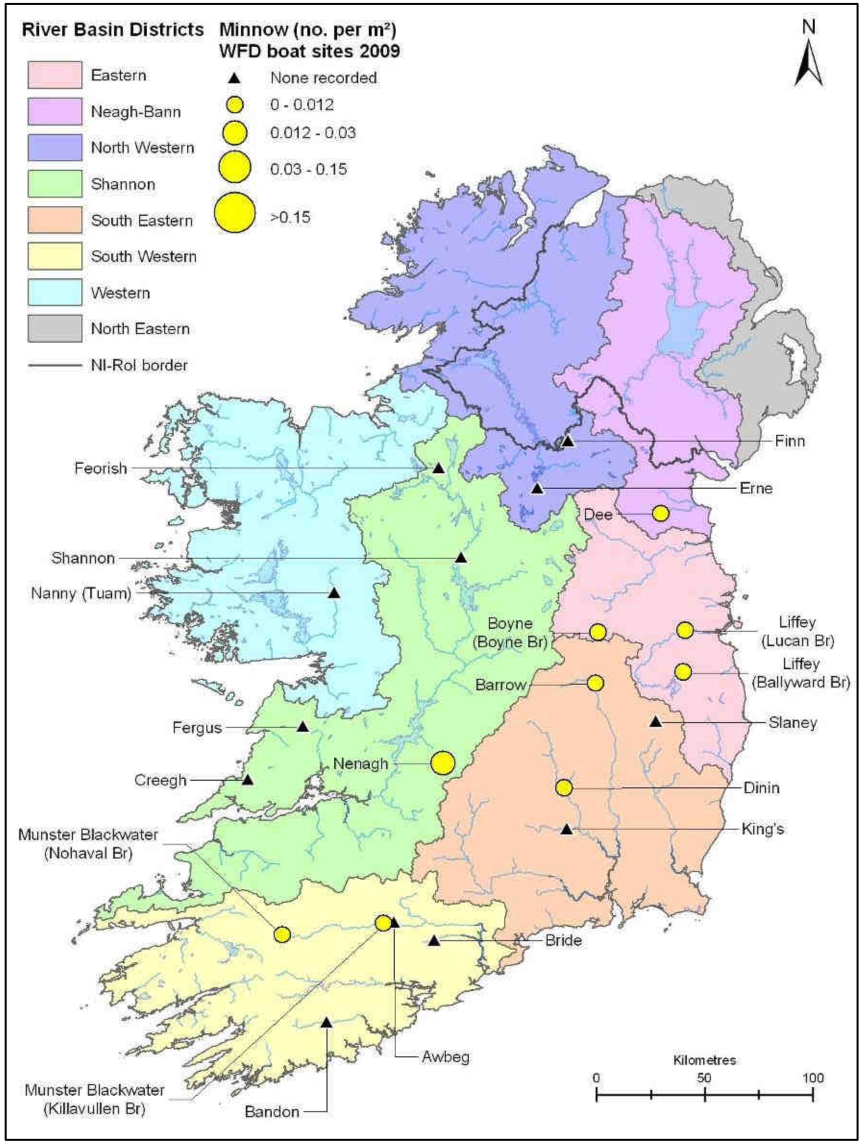

Fig. 4.69. Distribution and abundance of minnow at river boat sites surveyed for WFD monitoring 2009

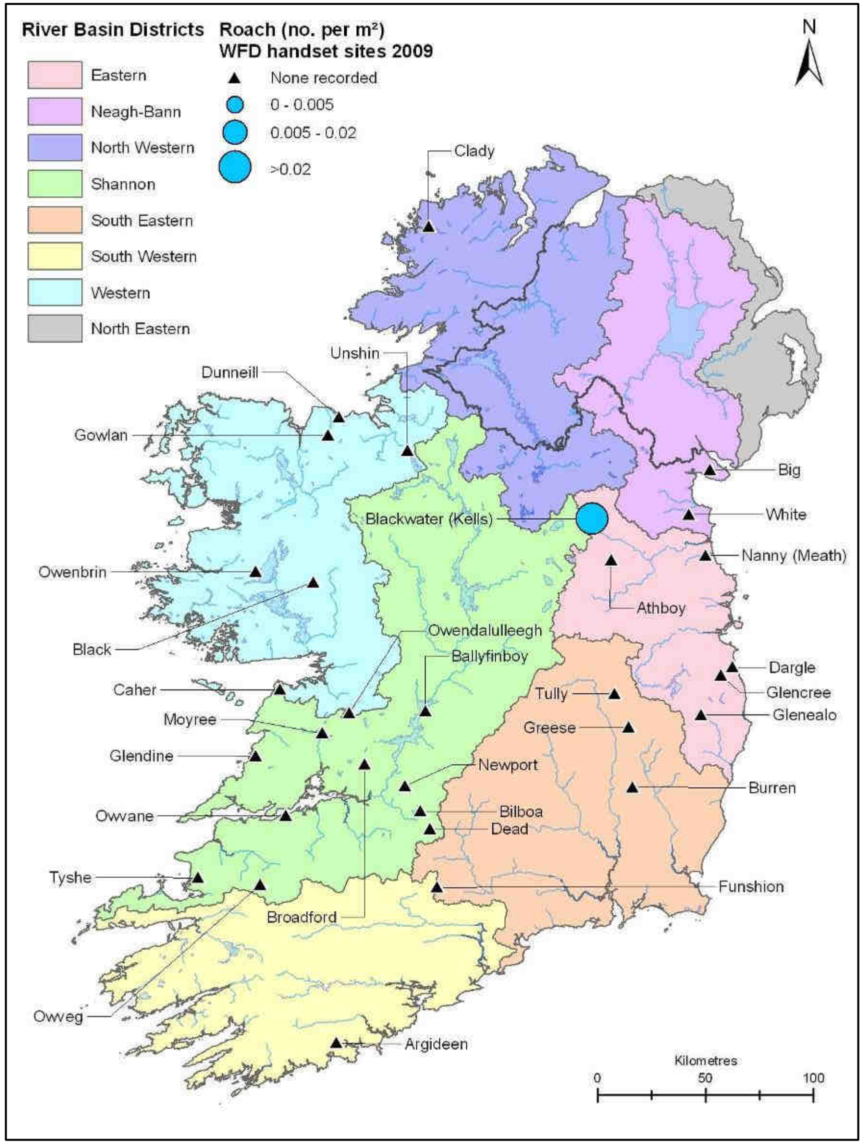

Fig. 4.70. Distribution and abundance of roach at river hand-set sites surveyed for WFD monitoring 2009

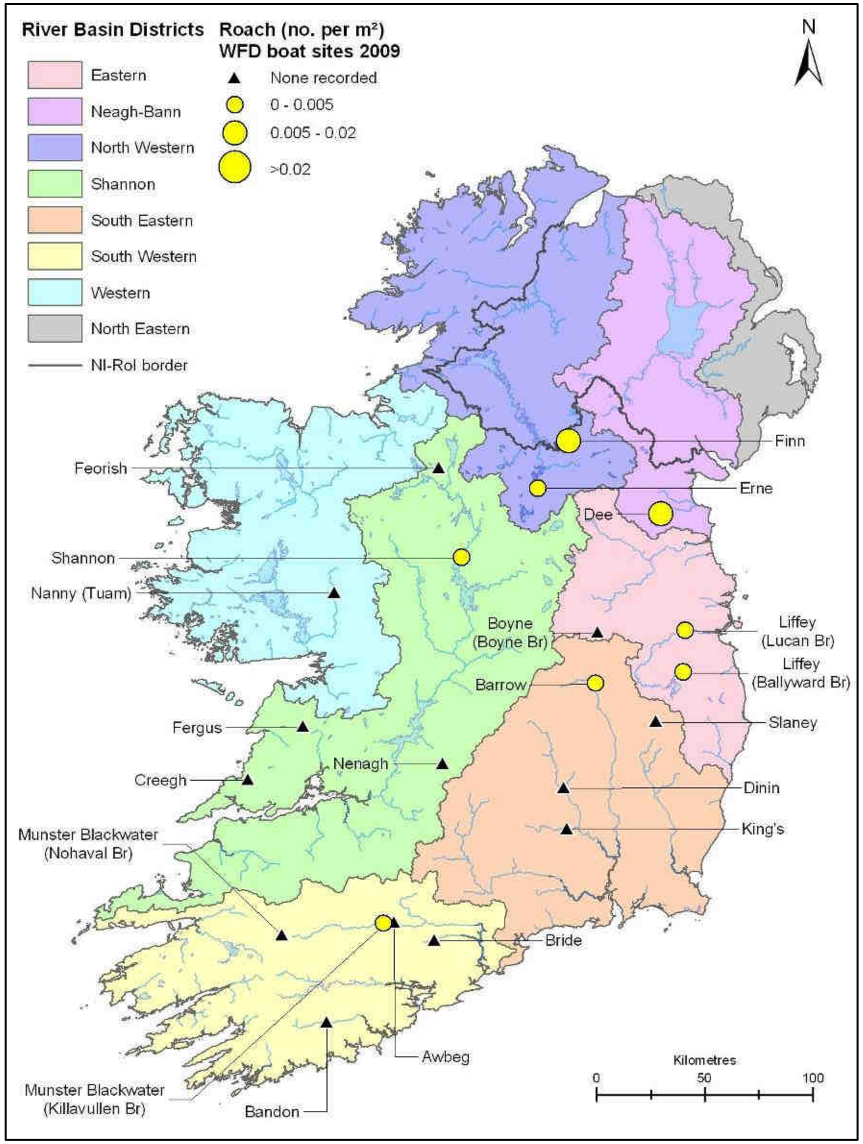

Fig. 4.71. Distribution and abundance of roach at river boat sites surveyed for WFD monitoring 2009

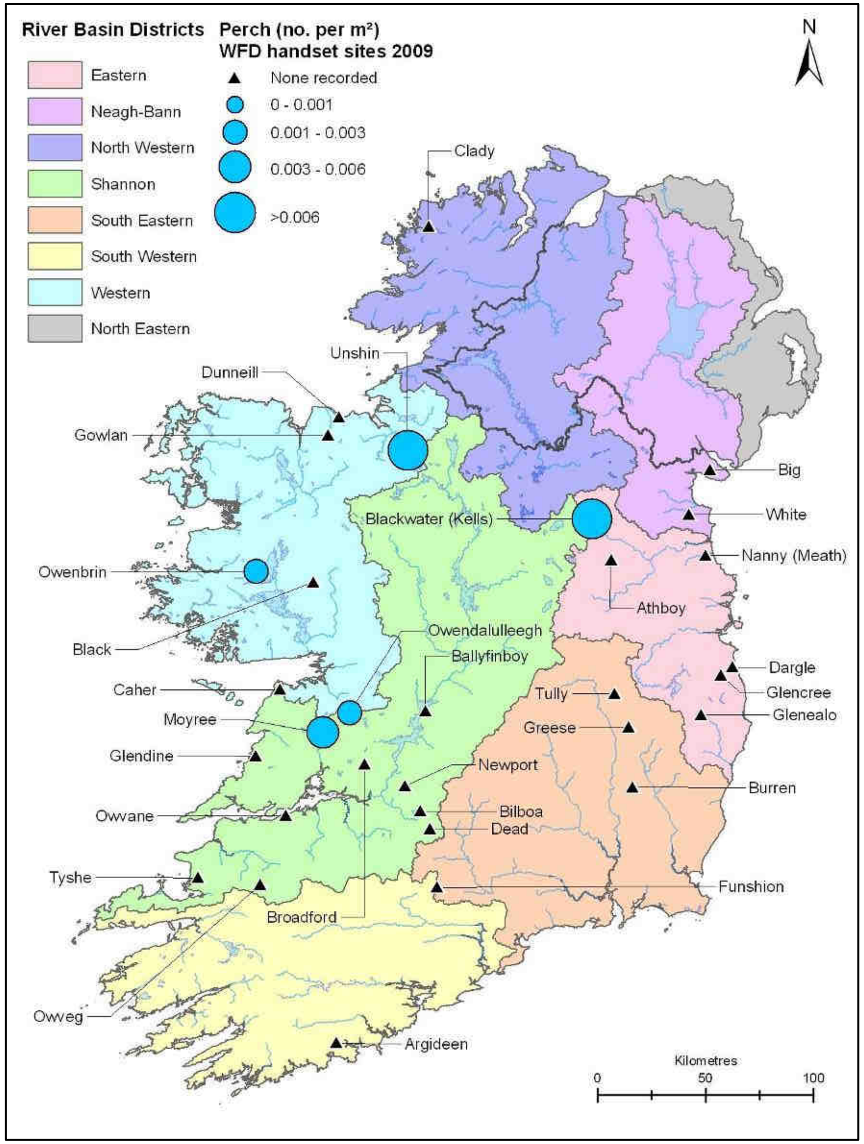

Fig. 4.72. Distribution and abundance of perch at river hand-set sites surveyed for WFD monitoring 2009

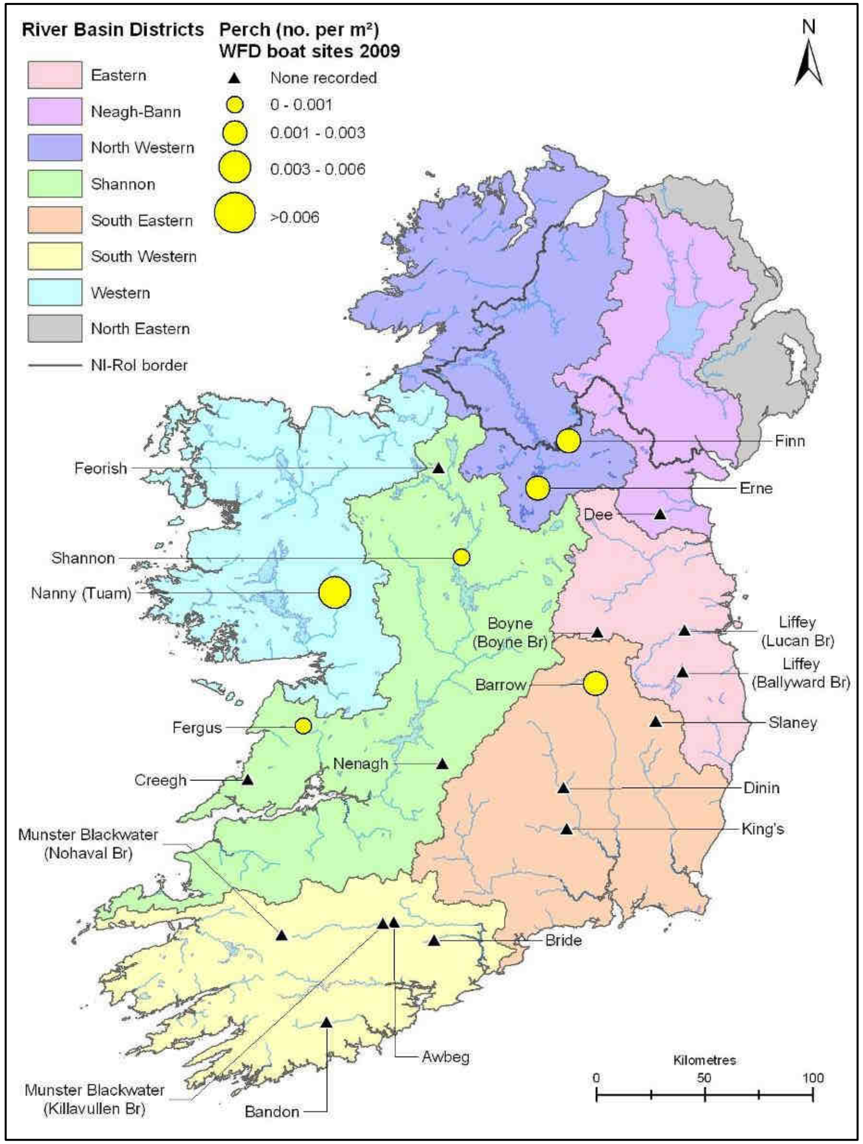

Fig. 4.73. Distribution and abundance of perch at river boat sites surveyed for WFD monitoring 2009

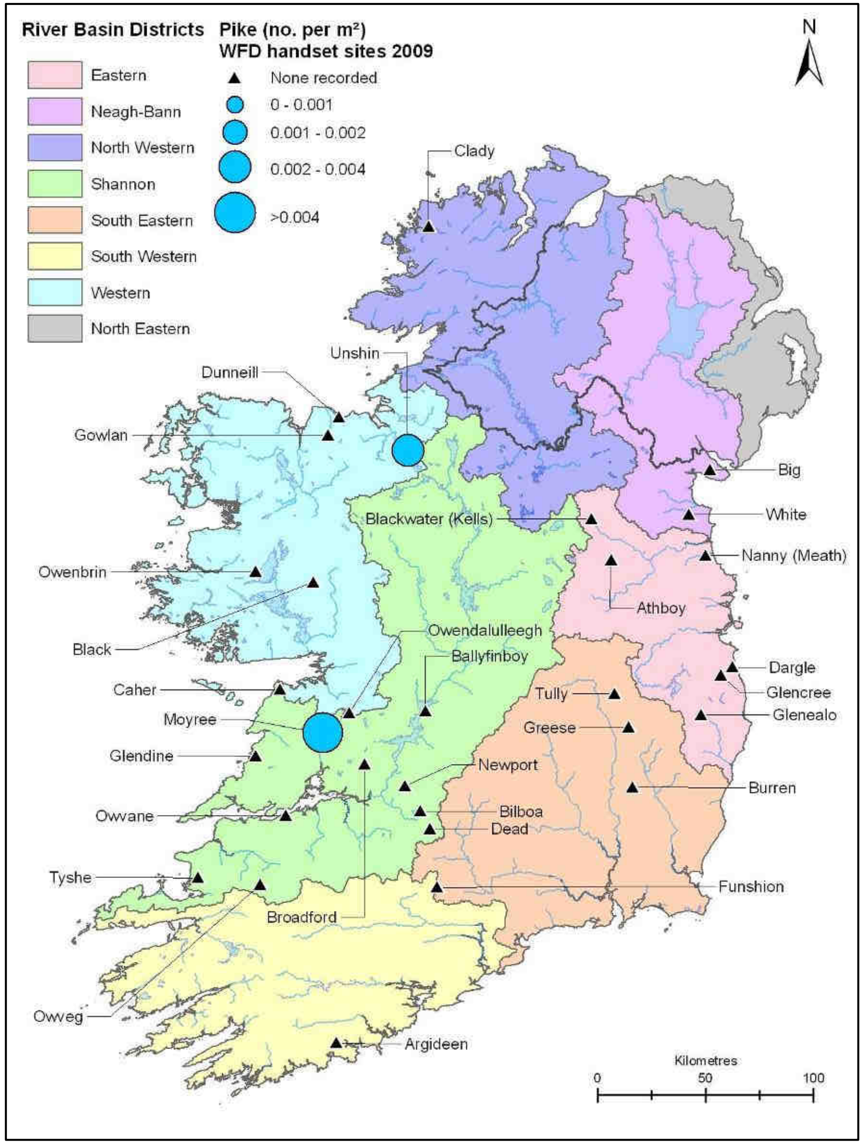

Fig. 4.74. Distribution and abundance of pike
at river hand-set sites surveyed for WFD monitoring 2009

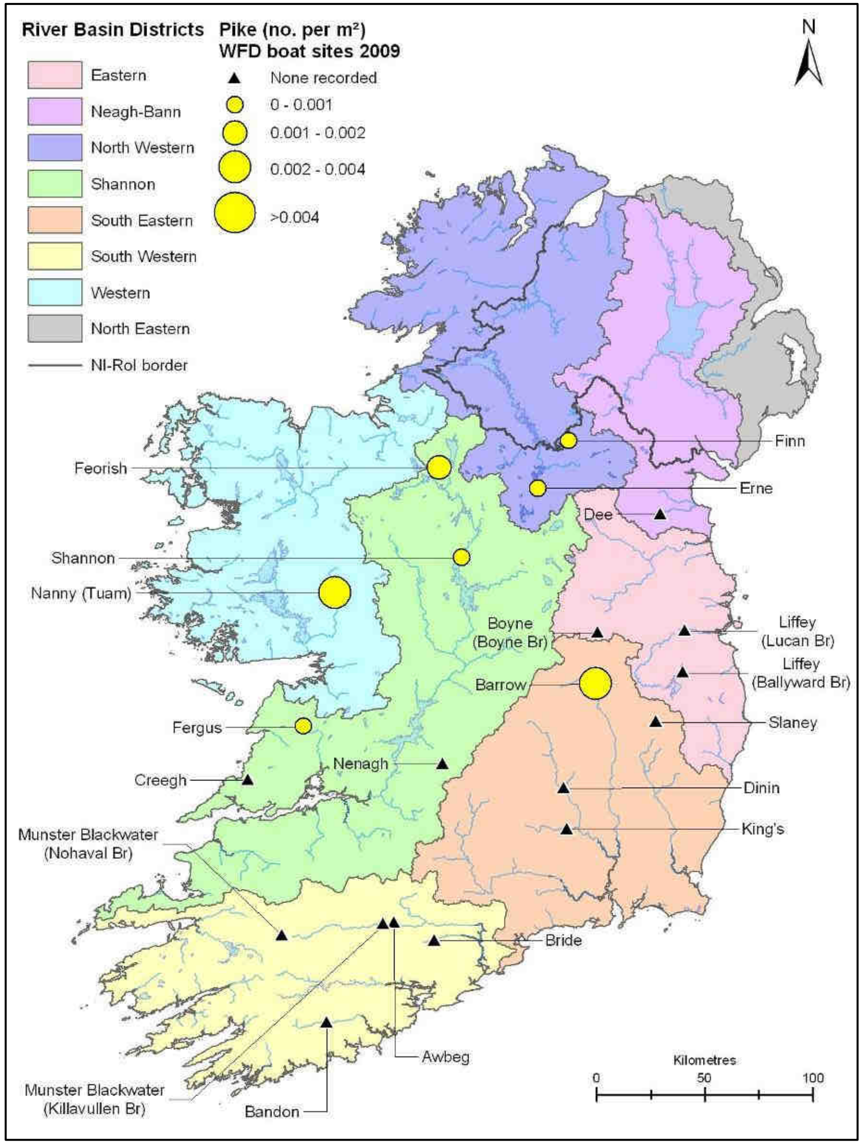

Fig. 4.75. Distribution and abundance of pike
at river boat sites surveyed for WFD monitoring 2009

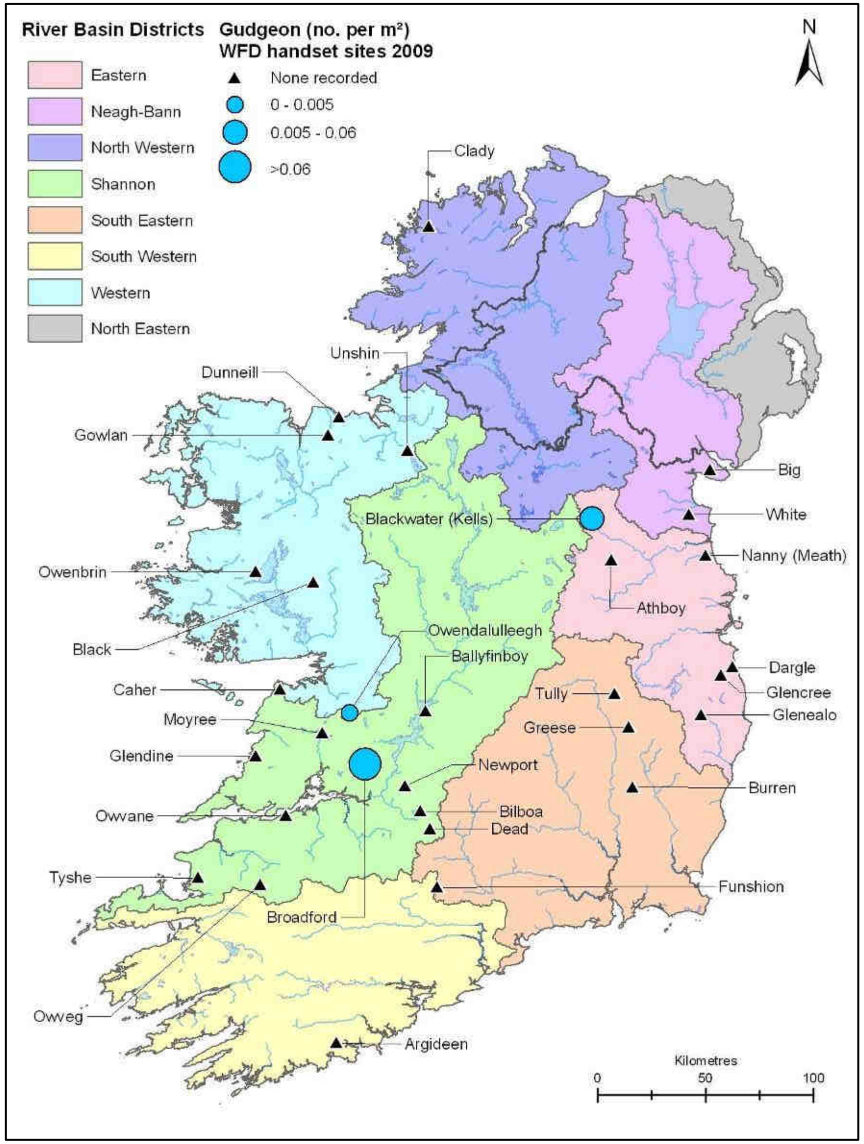

Fig. 4.76. Distribution and abundance of gudgeon at river hand-set sites surveyed for WFD monitoring 2009

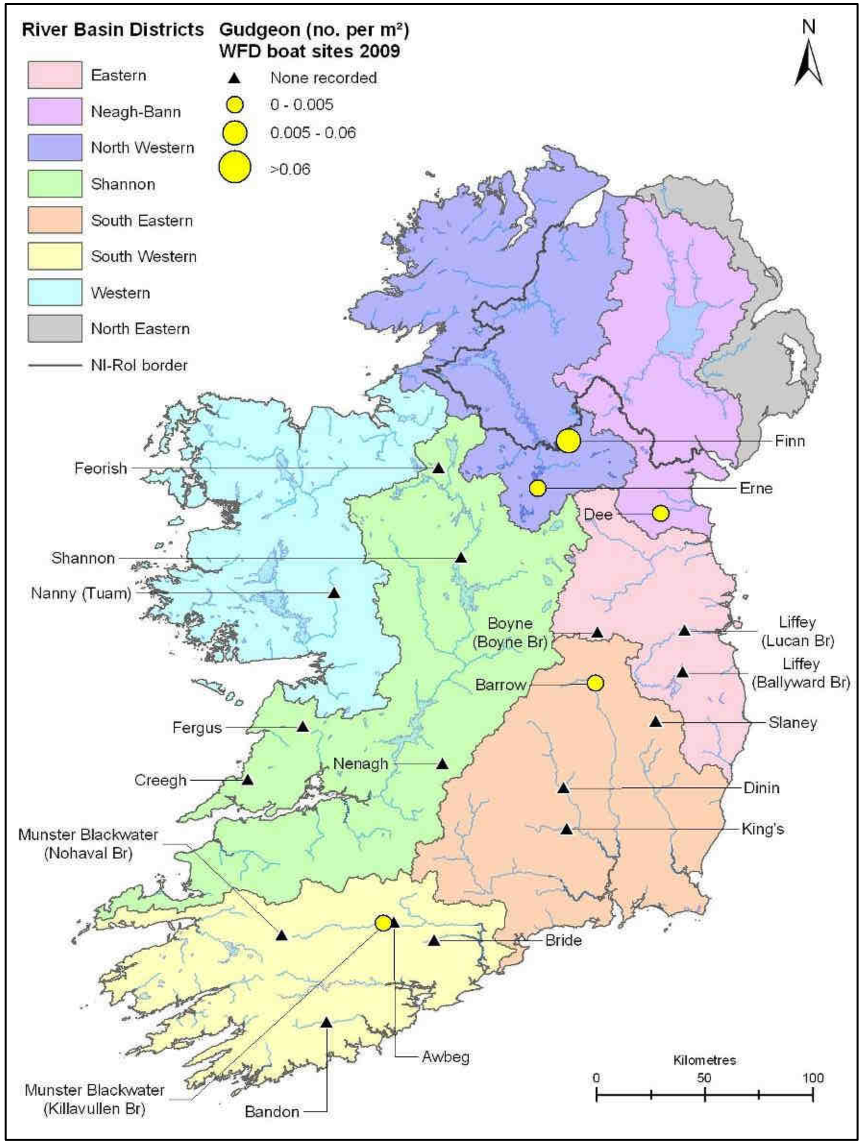

Fig. 4.77. Distribution and abundance of gudgeon at river boat sites surveyed for WFD monitoring 2009

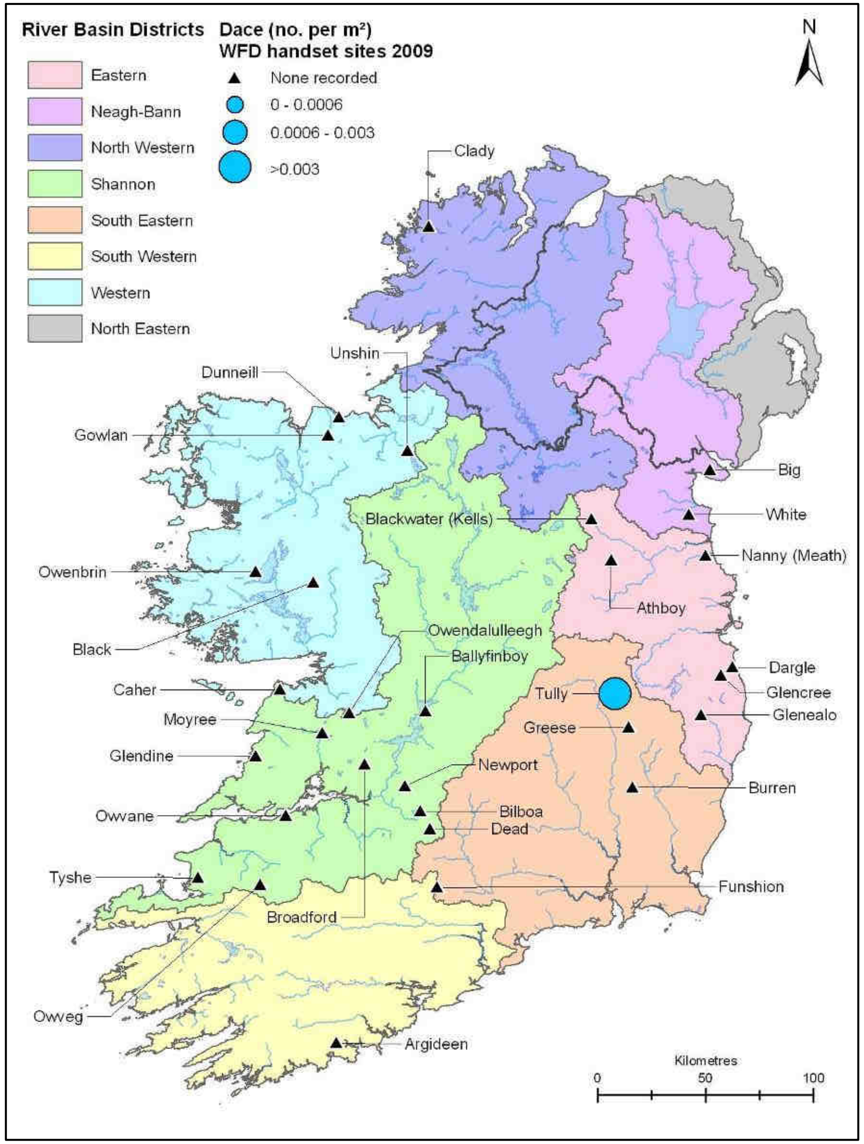

Fig. 4.78. Distribution and abundance of dace at river hand-set sites surveyed for WFD monitoring 2009

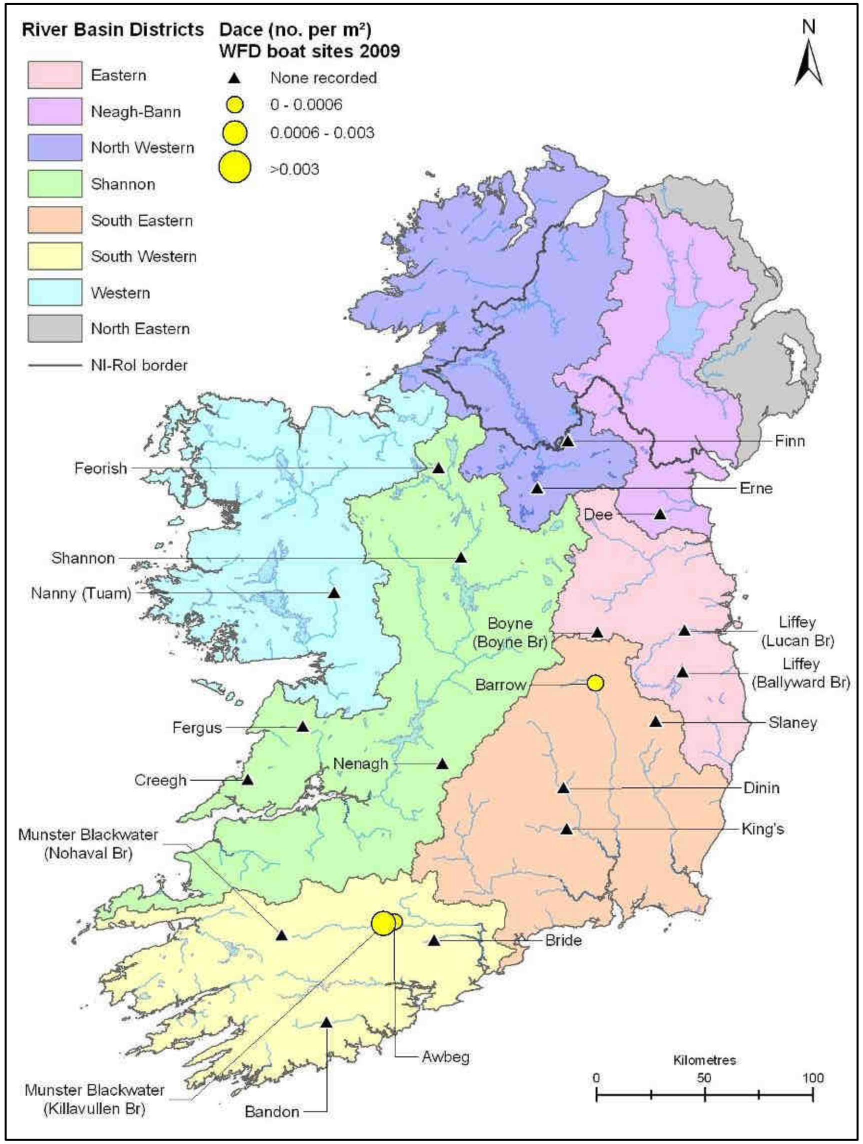

Fig. 4.79. Distribution and abundance of dace at river boat sites surveyed for WFD monitoring 2009

4.2.3 Fish growth

Scales from a total of 1,306 trout (50 river sites), 818 salmon (41 river sites), four sea trout (3 river sites), 103 roach (9 river sites), 52 pike (9 river sites), 1 bream (1 river site), 3 roach x bream hybrids (1 river site) and 42 dace (4 river sites), and opercular bones from 38 perch (11 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 6+. The most common ages were between 0+ and 3+, with older fish (4+ to 6+) being relatively rare. Only three brown trout aged 5+ and one aged 6+ were recorded. As expected, larger brown trout were usually found in the wider and deeper boat sites, whilst the younger age classes were more numerous in the shallower hand-set sites. The largest brown trout recorded during the survey was a 5+ fish which was captured in the River Liffey (Lucan) and measured 46.5cm in length and 1.18kg in weight. Appendix 6 provides a summary of the mean back-calculated length at age of brown trout in 45 river sites.

Salmon fry (0+) and parr (1+ and 2+) were the most common age groups recorded during the surveys. The largest juvenile salmon recorded (aged 2+), measuring 18.2cm in length and 91g in weight, was captured in the River Liffey (Lucan). Appendix 7 provides a summary of the mean back-calculated length at age of salmon in 36 rivers.

Roach ranged in age from 0+ to 6+. The oldest roach recorded was a 6 year old fish, captured in the River Liffey (Ballyward) in Co. Wicklow. The largest roach recorded (River Shannon, Ballyleague Bridge) was a 5 year old individual which measured 27.6cm and weighed 0.44kg. The oldest perch was captured on the River Barrow at Pass Bridge and was aged 8+, measuring 34.1cm in length and 0.95kg in weight. The largest and oldest pike recorded (6+) was caught in the River Erne at Bellahillan Bridge, measuring 69.0cm and weighing 2.31kg.

4.2.3.1 Growth of brown trout

For each river, the back-calculated mean length of trout at L2, L3 and L4 was compared to the back-calculated mean lengths described by Kennedy and Fitzmaurice (1971) (as shown in Table 4.7) and assigned to growth categories. The back calculated lengths for brown trout surveyed during 2009 are shown in Appendix 6. The alkalinity ranges observed for the four growth categories during 2009 are shown in parentheses and appear to differ quite noticeably from the observations of Kennedy and Fitzmaurice (Table 4.7).

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 (2.8 – 110.0)
Slow	13–14	18–19	20–21	25.0 – 100.1 (1.6 – 345.0)
Fast	18–20	24–25	29–30	25.0 – 140.1 (22.0 – 320.0)
Very fast	20	30	35–40	>150.1 (167.0 – 351.0)

The 2009 surveillance monitoring river sites were grouped according to the categories proposed by Kennedy and Fitzmaurice (1971). Eight river sites were classed as very slow, 19 were classed as slow, 12 were classed as fast and three were classed as very fast (Table 4.8). Grouping growth rate categories in this way requires the availability of L2 – L4 information. Seven of the rivers surveyed had no fish old enough for this purpose and as a result are not included below.

Table 4.8. Categories of growth of brown trout in the WFD river sites 2009 using Kennedy and Fitzmaurice (1971)

Very slow	Slow	Fast	Very fast
Big (Louth)	Argideen	Barrow (Pass Br.)	Black (Shrule)
Blackwater (Kells)	Athboy	Boyne (Boyne Br.)	Fergus
Burren	Awbeg (Buttevant)	Bride	Liffey (Lucan)
Funshion	Ballyfinboy	Dead	
Glencree	Bilboa	Dee	
Glenealo	Blackwater (Killavullen)	Finn (Monaghan)	
Owenbrin	Blackwater (Nohaval)	Greese	
Slaney	Clady (Donegal)	Nanny (Tuam)	
	Creegh	Owendalulleegh	
	Dargle	Owveg (Kerry)	
	Dinin	Tully Stream	
	Dunneill	Unshin	
	Glendine (Clare)		
	Gowlan		
	King's (Kilkenny)		
	Liffey (Ballyward Br.)		
	Nenagh		
	Newport		
	White (Louth)		

The rivers that had trout present were also divided up into three categories based on their alkalinity; these were low = <35 mg$CaCO_3$ l^{-1}, moderate = 35 – 100 mg$CaCO_3$ l^{-1}, and high > 100 mg$CaCO_3$ l^{-1}. Ten were characterised as low alkalinity, 12 moderate alkalinity and 25 high alkalinity. Three rivers were excluded where fry (0+) only were captured. Statistical analyses (One-way ANOVA) were conducted to assess the differences in mean length at age among alkalinity groups for L1 to L5 (Fig.4.80). There was a significant difference in mean L1 among alkalinity groups ($F_{2,46}$=11.675, p<0.001), with Fishers Least Significant Difference (FLSD) post-hoc test showing that mean L1 was significantly lower in low alkalinity lakes when compared to both moderate and high alkalinity lakes, which weren't significantly different from each other. There was a significant difference in mean L2 among alkalinity groups ($F_{2,43}$=11.187, p<0.001), with FLSD post-hoc test showing that mean L2 was significantly lower in low alkalinity lakes when compared to both moderate and high alkalinity lakes, which weren't significantly different from each other. There was also a significant difference in mean L3 among alkalinity groups ($F_{2,27}$=3.794, p<0.05), with FLSD post-hoc test showing that mean L3 was significantly lower in low alkalinity lakes when compared to high alkalinity lakes, but not moderate alkalinity lakes, which weren't significantly different from each other. There was no significant difference in mean L4 and mean L5 between alkalinity groups.

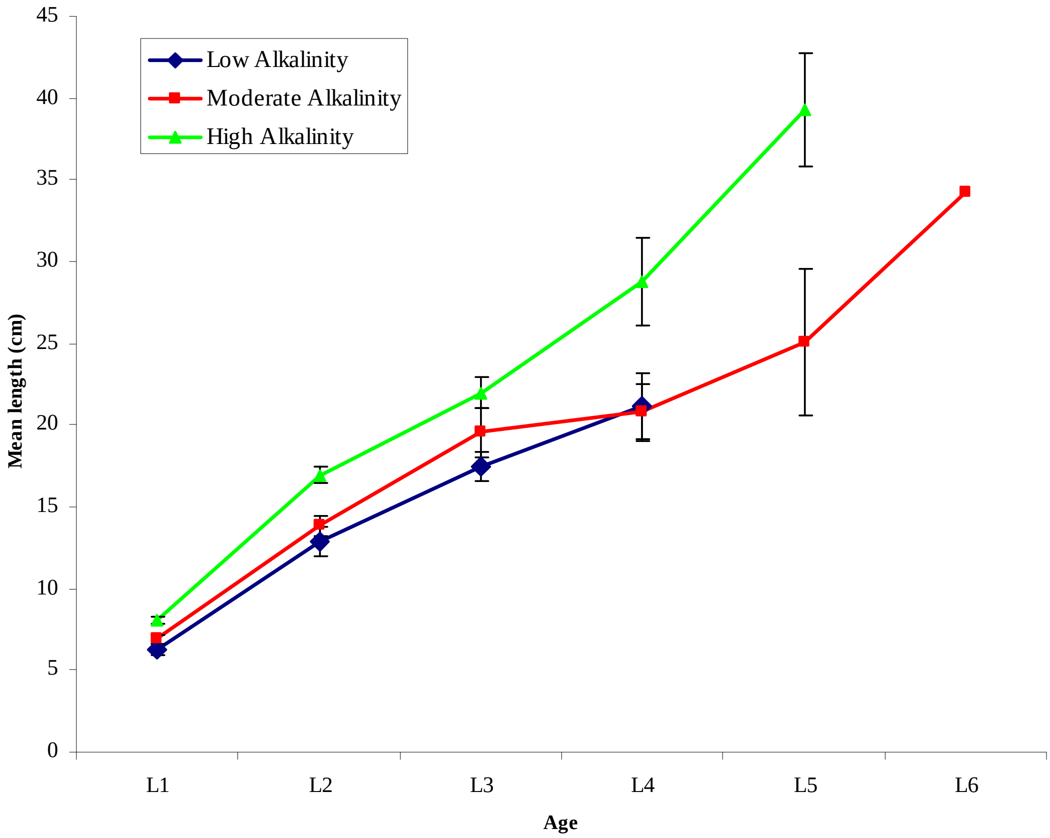

Fig. 4.80. Mean (±S.E.) back calculated length at age for brown trout in rivers within each alkalinity class

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. 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).

Overall, a total of 56 fish species (sea trout are included as a separate “variety” of trout) were recorded from 23 transitional water bodies surveyed during 2009 (Table 4.9). 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. 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).

The three most frequently encountered species recorded during the 2009 surveys were European eel (96%), followed by flounder (87%) and sand goby (78%). Commercially important species such as cod, thick-lipped grey mullet and plaice were recorded in 57%, 39% and 57% of transitional water bodies respectively. Seventeen fish species were present in 10% to 30% of the water bodies and 21 species were recorded in less than 10% of the water bodies (Table 4.9).

Species richness ranged from two species on Lough Muree to a maximum of 32 species on Lough Swilly (Table 4.10, Fig. 4.81). Five estuaries recorded 20 or more fish species (Lough Swilly, Lower Bandon, Camus Bay, Boyne Estuary and Inner Donegal Bay), whereas less than ten species were recorded in 11 estuaries.

Table 4.9. Species present in transitional water bodies surveyed during 2009

	Scientific name	Common name	Number of transitional water bodies	% transitional water bodies
1	*Anguilla anguilla*	European eel	22	96
2	*Platichthys flesus*	Flounder	20	87
3	*Pomatoschistus minutus*	Sand goby	18	78
4	*Gasterosteus aculeatus*	3-Spined Stickleback	17	74
5	*Gadus morhua*	Cod	13	57
6	*Pleuronectes platessa*	Plaice	13	57
7	*Ciliata mustela*	5-Bearded rockling	12	52
8	*Taurulus bubalis*	Long-spined sea scorpion	11	48
9	*Pollachius pollachius*	Pollack	10	43
10	*Chelon labrosus*	Thick-lipped grey mullet	9	39
11	*Myoxocephalus scorpius*	Short-spined sea scorpion	9	39
12	*Spinachia spinachia*	15-spined stickleback	8	35
13	*Sprattus sprattus*	Sprat	8	35
14	*Ammodytes tobianus*	Lesser sandeel	7	30
15	*Merlangus merlangus*	Whiting	7	30
16	*Salmo trutta*	Brown trout	7	30
17	*Salmo trutta*	Sea trout **	7	30
18	*Syngnathus acus*	Greater pipefish	7	30
19	*Atherina prebyter*	Sand smelt	6	26
20	*Gobius paganellus*	Rock goby	6	26
21	*Pholis gunnellus*	Gunnel (Butterfish)	5	22
22	*Trispterus luscus*	Bib	5	22
23	*Agonus cataphractus*	Pogge	4	17
24	*Clupea harengus*	Herring	4	17
25	*Limanda limanda*	Dab	4	17
26	*Lipophrys pholis*	Shanny	4	17
27	*Salmo salar*	Salmon *	4	17
28	*Scophthalmus rhombus*	Brill	4	17
29	*Syngnathus typhle*	Deep-snouted pipefish	4	17
30	*Trisopterus minutus*	Poor cod	4	17
31	*Callionymus sp.*	Dragonet sp.	3	13
32	*Gobiusculus flavescens*	2-spotted goby	3	13
33	*Pollachius virens*	Saithe (Coalfish)	3	13
34	*Pomatoschistus pictus*	Painted goby	3	13
35	*Scardinius erythrophthalmus*	Rudd	3	13
36	*Centrolabrus exoletus*	Rock cook wrasse	2	9
37	*Gobius niger*	Black goby	2	9
38	*Labrus bergylta*	Ballan wrasse	2	9
39	*Phoxinus phoxinus*	Minnow	2	9
40	*Pomatoschistus microps*	Common goby	2	9
41	*Raja clavata*	Thornback ray	2	9
42	*Rutilus rutilus*	Roach	2	9
43	*Scyliorhinus canicula*	Lesser spotted dogfish	2	9
44	*Scyliorhinus stellaris*	Bull huss	2	9
45	*Solea solea*	Common sole	2	9
46	*Symphodus melops*	Corkwing wrasse	2	9
47	*Aspitrigla cuculus*	Red gurnard	1	4
48	*Ctenolabrus rupestris*	Goldsinny	1	4
49	*Entelrus aequoreus*	Snake pipefish	1	4
50	*Gaidropsarus vulgaris*	3-bearded rockling	1	4
51	*Hyperoplus lanceolatus*	Greater sandeel	1	4
52	*Lampetra sp.*	Lamprey *	1	4
53	*Liparis liparis*	Common seasnail	1	4
54	*Mustelus mustelus*	Smooth hound	1	4
55	*Pegusa lascaris*	Sand sole	1	4
56	*Pungitius pungitius*	9-spined stickleback	1	4

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

Table 4.10. Species richness and most abundant species present in transitional water bodies surveyed during 2009

Water body	Type	Species Richness	Most abundant species
Swilly Estuary	Transitional	32	Sand Goby
Bandon Estuary, Lower	Transitional	28	Sand Goby
Camus Bay	Transitional	27	3-spined Stickleback
Boyne Estuary	Transitional	23	Sprat
Donegal Bay, Inner	Transitional	21	Lesser Sandeel
Kinvarra Bay	Transitional	18	Sand Goby
Bridgetown Estuary	Transitional	17	Sand Goby
Dundalk Bay, Inner	Transitional	16	Sprat
Gweebarra Estuary	Transitional	16	Lesser Sandeel
Erne Estuary	Transitional	16	Lesser Sandeel
Slaney Estuary, Lower	Transitional	15	Sand Goby
Castletown Estuary	Transitional	11	Flounder
Loughaunavneen	Lagoon	9	3-spined Stickleback
Athola, Lough	Lagoon	9	Eel
Inch Lough	Lagoon	8	3-spined Stickleback
Slaney Estuary, Upper	Freshwater Tidal	7	3-spined Stickleback
Ladys Island Lake	Lagoon	7	Sand Goby
Durnesh Lough	Lagoon	6	Sand Goby
North Slob Channels	Lagoon	5	3-spined Stickleback
Tacumshin Lake	Lagoon	5	3-spined Stickleback
Bandon Estuary, Upper	Freshwater Tidal	5	Flounder
Bridge Lough	Lagoon	3	Thick-lipped Grey Mullet
Muree, Lough	Lagoon	2	3-spined Stickleback

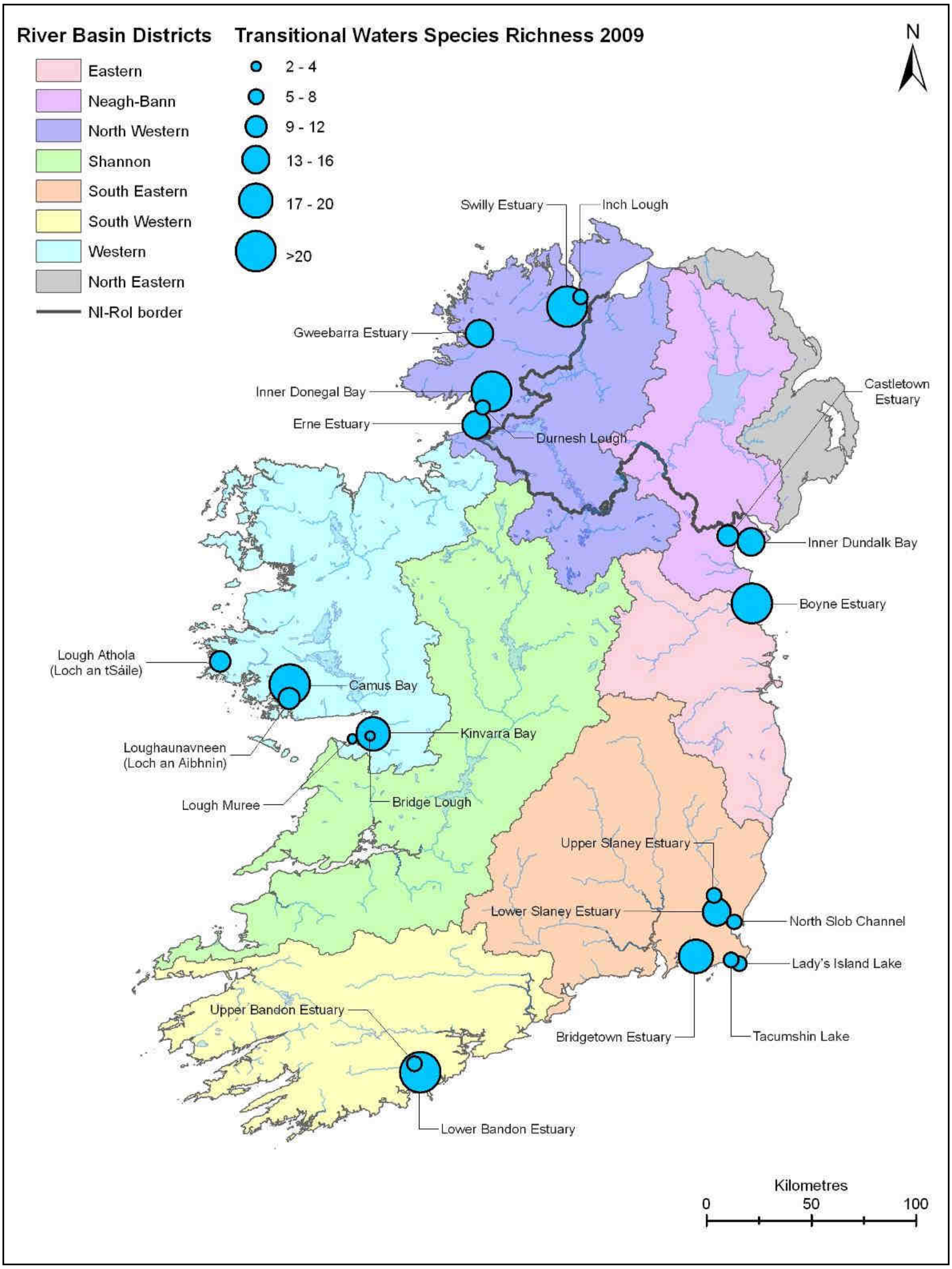

Fig. 4.81. Species richness in the 23 transitional water bodies surveyed during 2009

4.3.2 Fish species distribution

A large number of juvenile and immature fish of a range of species were captured within the various waters surveyed, indicating the important nursery function of many transitional water bodies. Figures 4.82 to 4.90 show the distribution of a selected number of the more abundant or important fish species; eel, flounder, sand goby, salmon, brown trout, cod, pollack, sea trout and thick-lipped grey mullet.

Four species of angling importance were recorded; flounder (Plate 4.1, Fig. 4.83) were captured in 20 water bodies distributed throughout the country, pollack (Fig. 4.88) were recorded in ten water bodies, sea trout (Plate 4.2, Fig. 4.89) were recorded in seven water bodies and thick-lipped grey mullet (Plate 4.3, Fig 4.90) were recorded in nine water bodies.

Plate 4.1. Flounder captured in the Lower Bandon Estuary, October 2009

Plate 4.2. Sea trout captured in Inch Lough, October 2009

Plate 4.3. Thick-lipped grey mullet captured in Inner Dundalk Bay, September 2009

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. Seventeen of the transitional water bodies surveyed during 2009 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 (code 1150) and estuaries (code 1130). Protected species that may be expected to occur in these habitats include river lamprey, sea lamprey, Atlantic salmon (only designated in freshwater), smelt, allis shad and twaite shad. Of these species, lamprey were recorded in the Upper Slaney Estuary and salmon were recorded in four estuaries; Boyne Estuary, Upper Slaney Estuary, Lower Bandon Estuary and Inch Lough (Fig. 4.85).

European eels are listed as a declining species and are 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 in fyke nets during 2009 (22 out of 23 transitional water bodies, Fig. 4.82) and data from these WFD surveys will also be used to support the National Eel Management Plan. Smelt, considered an indicator of good water quality, were not recorded at any water bodies surveyed during 2009.

Two freshwater species (rudd and roach) were also recorded during 2009. Most were found in water bodies that were classified as lagoons, where salinities were low. Three roach were captured in the Boyne Estuary, however these were captured at sites near the upper tidal limit with salinities of <1ppt.

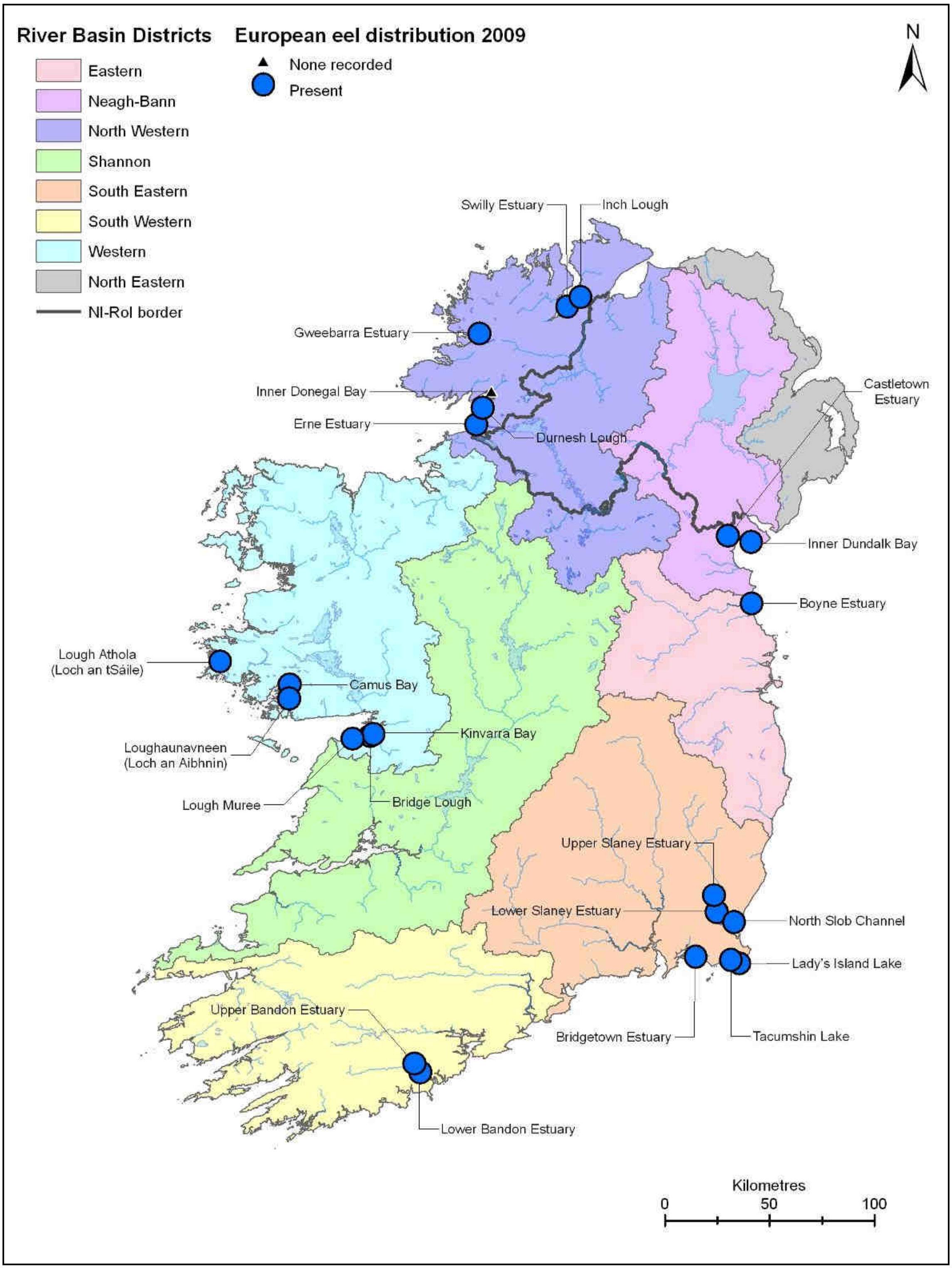

Fig 4.82. European eel distribution in transitional waters surveyed for WFD fish monitoring, 2009

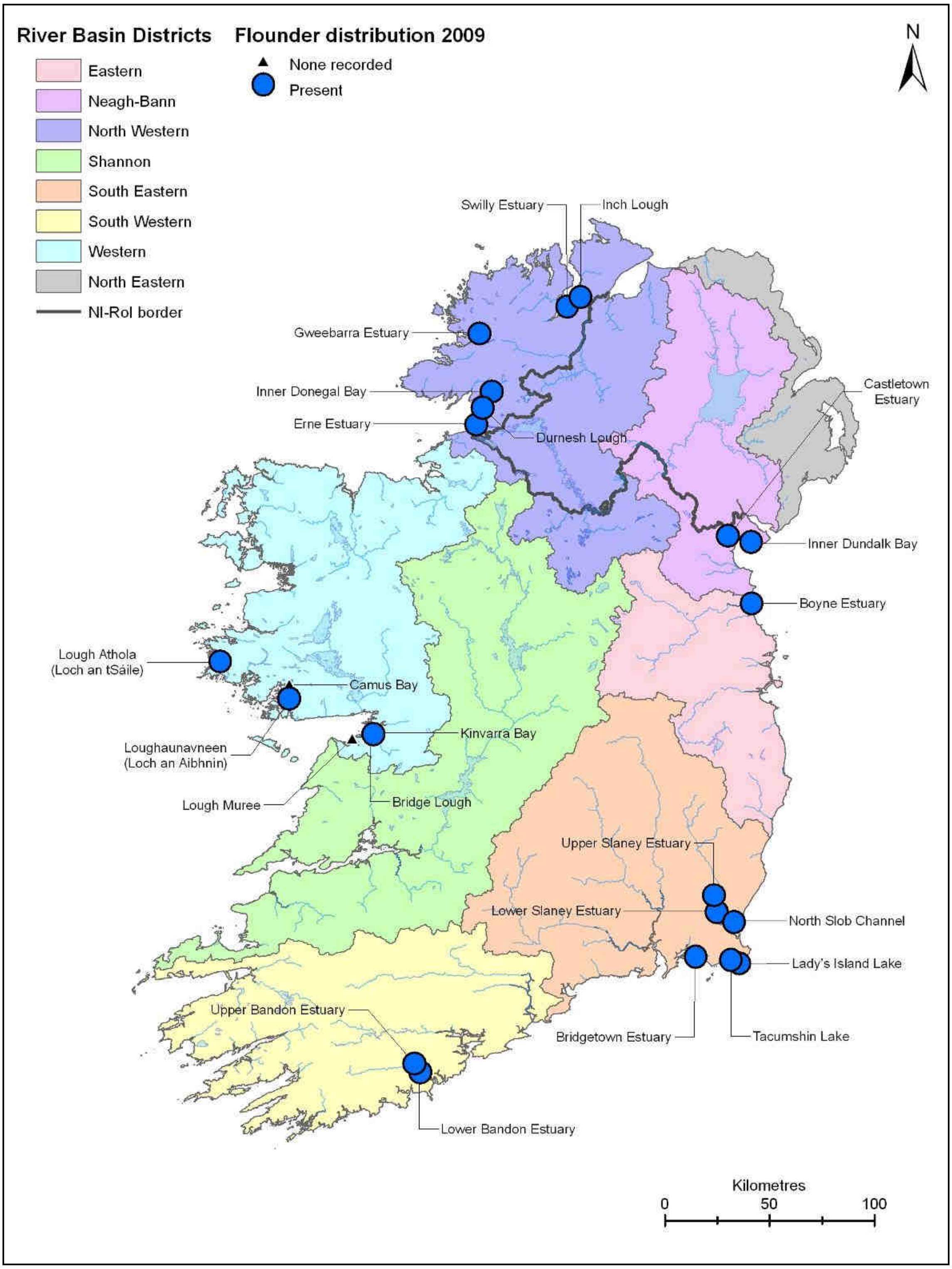

Fig 4.83. Flounder distribution in transitional waters surveyed for WFD fish monitoring, 2009

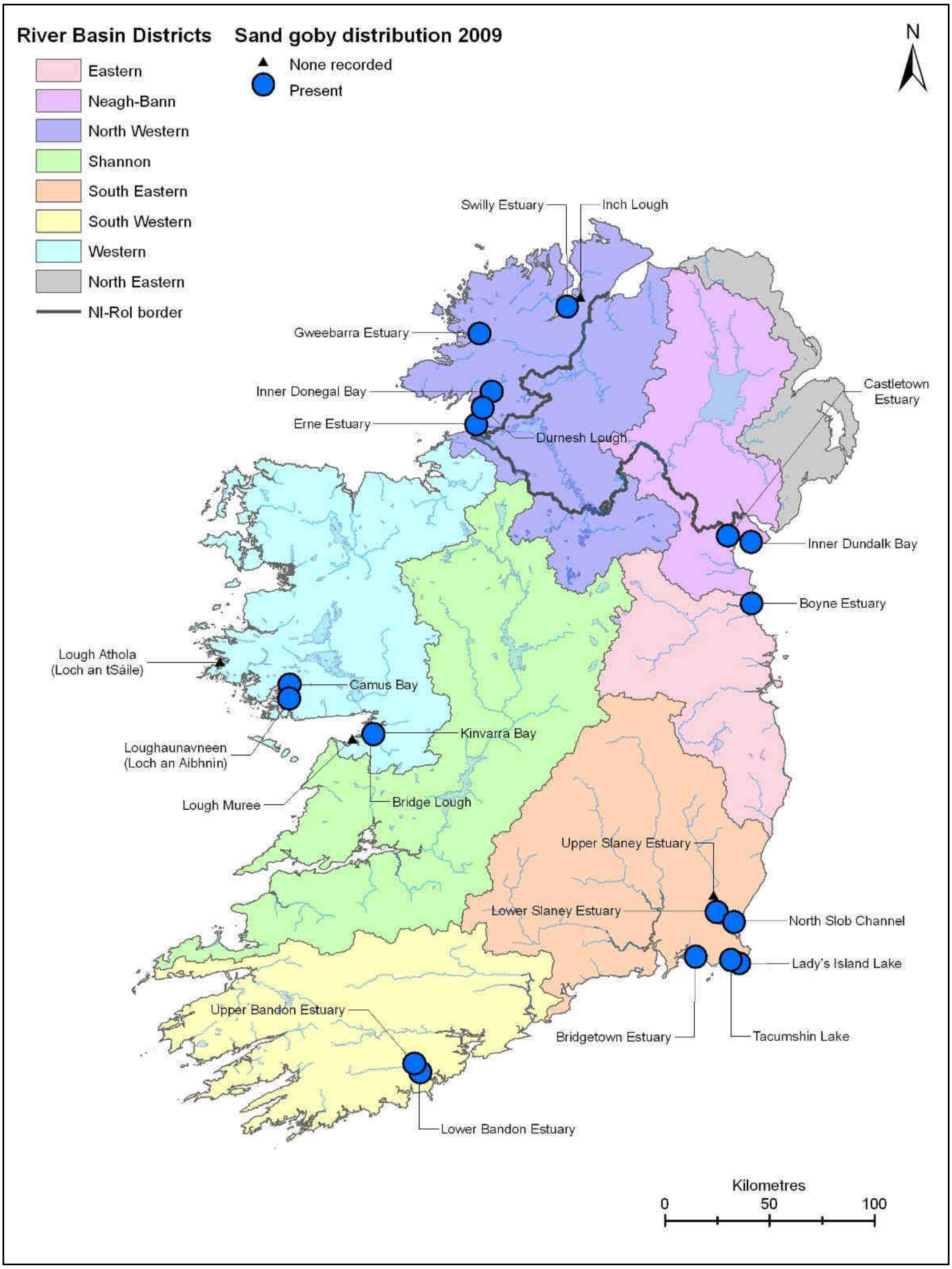

Fig 4.84. Sand goby distribution in transitional waters surveyed for WFD fish monitoring, 2009

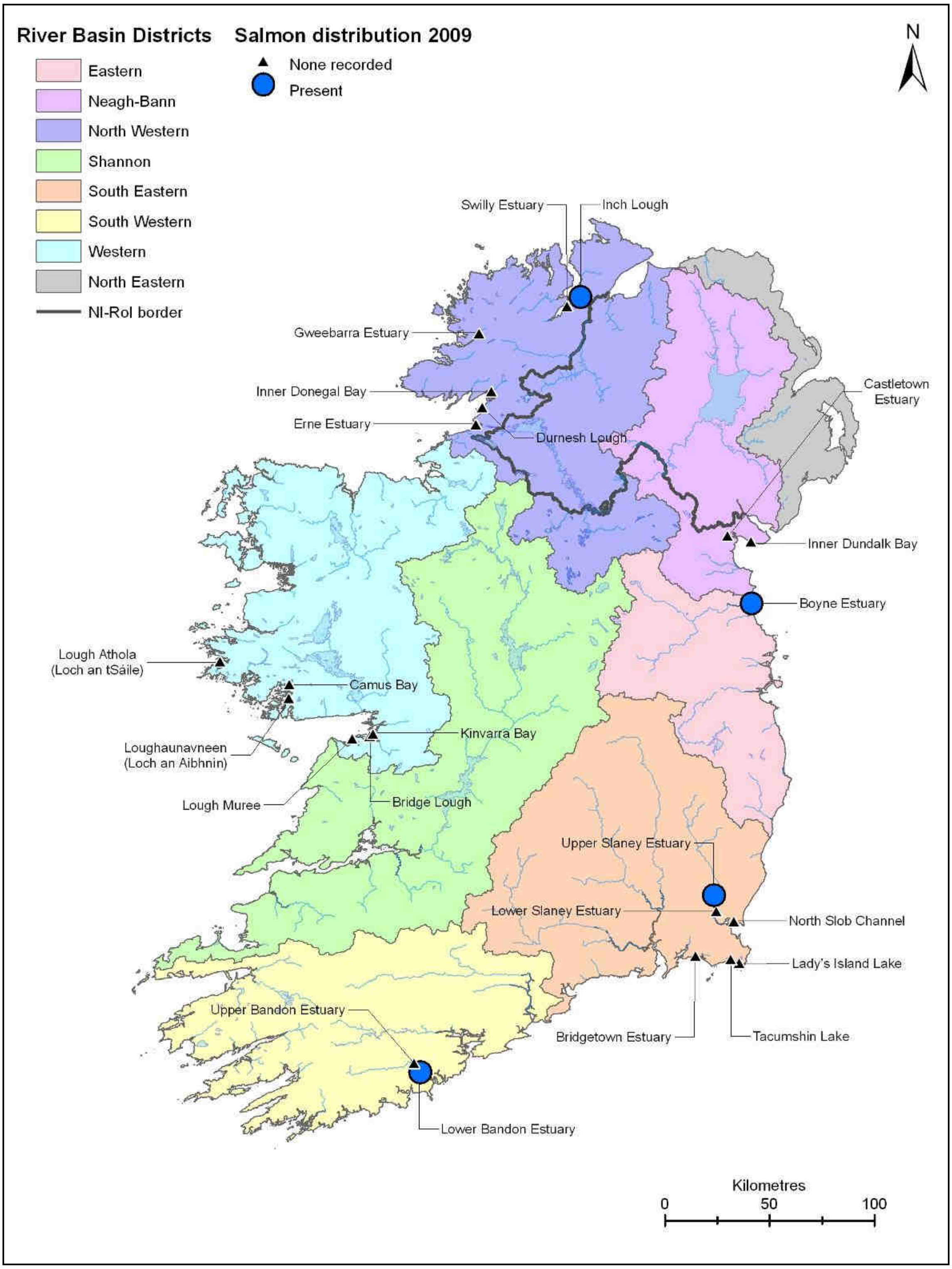

Fig 4.85. Salmon distribution in transitional waters surveyed for WFD fish monitoring, 2009

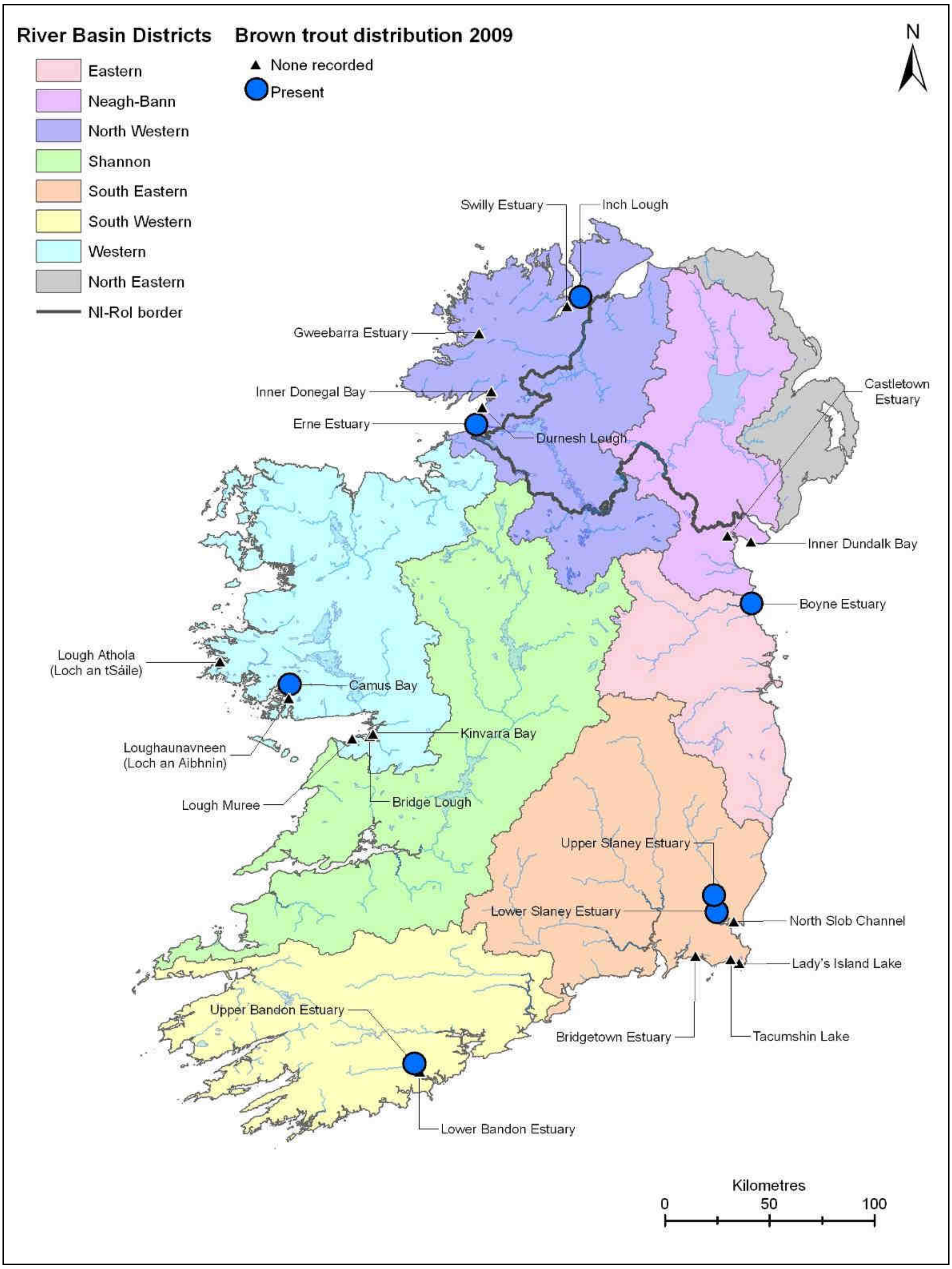

Fig 4.86. Brown trout distribution in transitional waters surveyed for WFD fish monitoring, 2009

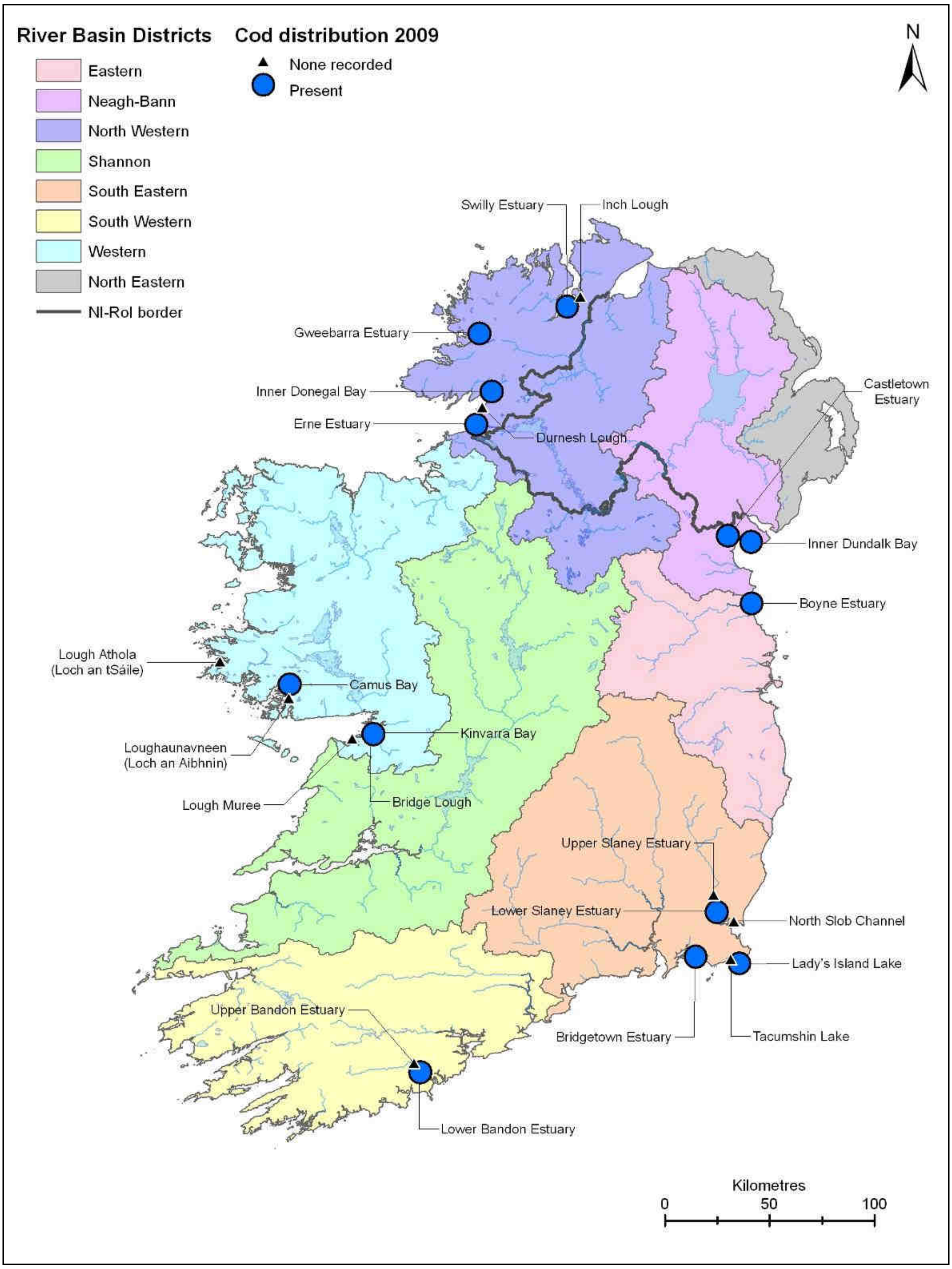

Fig 4.87. Cod distribution in transitional waters surveyed for WFD fish monitoring, 2009

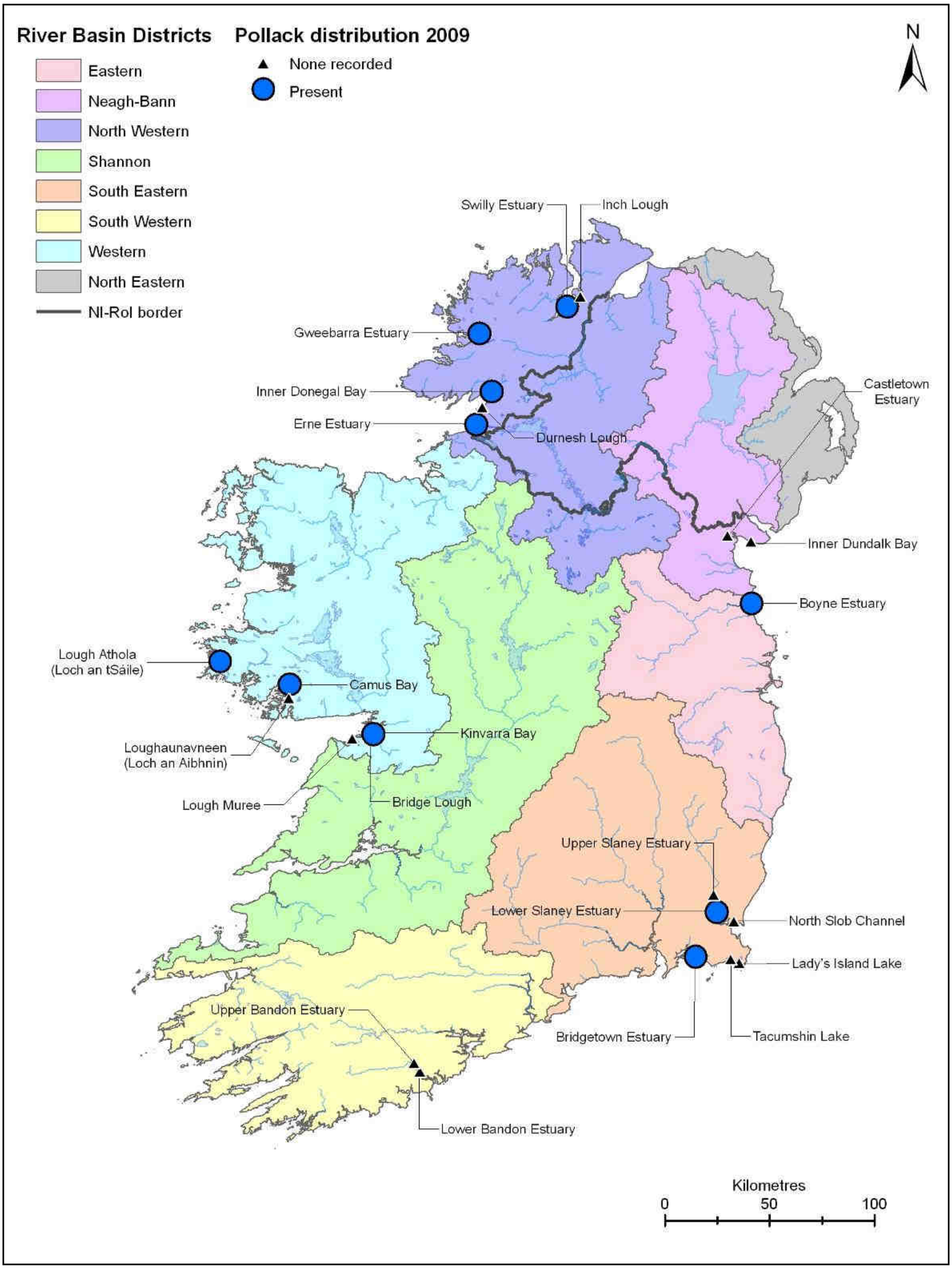

Fig 4.88. Pollack distribution in transitional waters surveyed for WFD fish monitoring, 2009

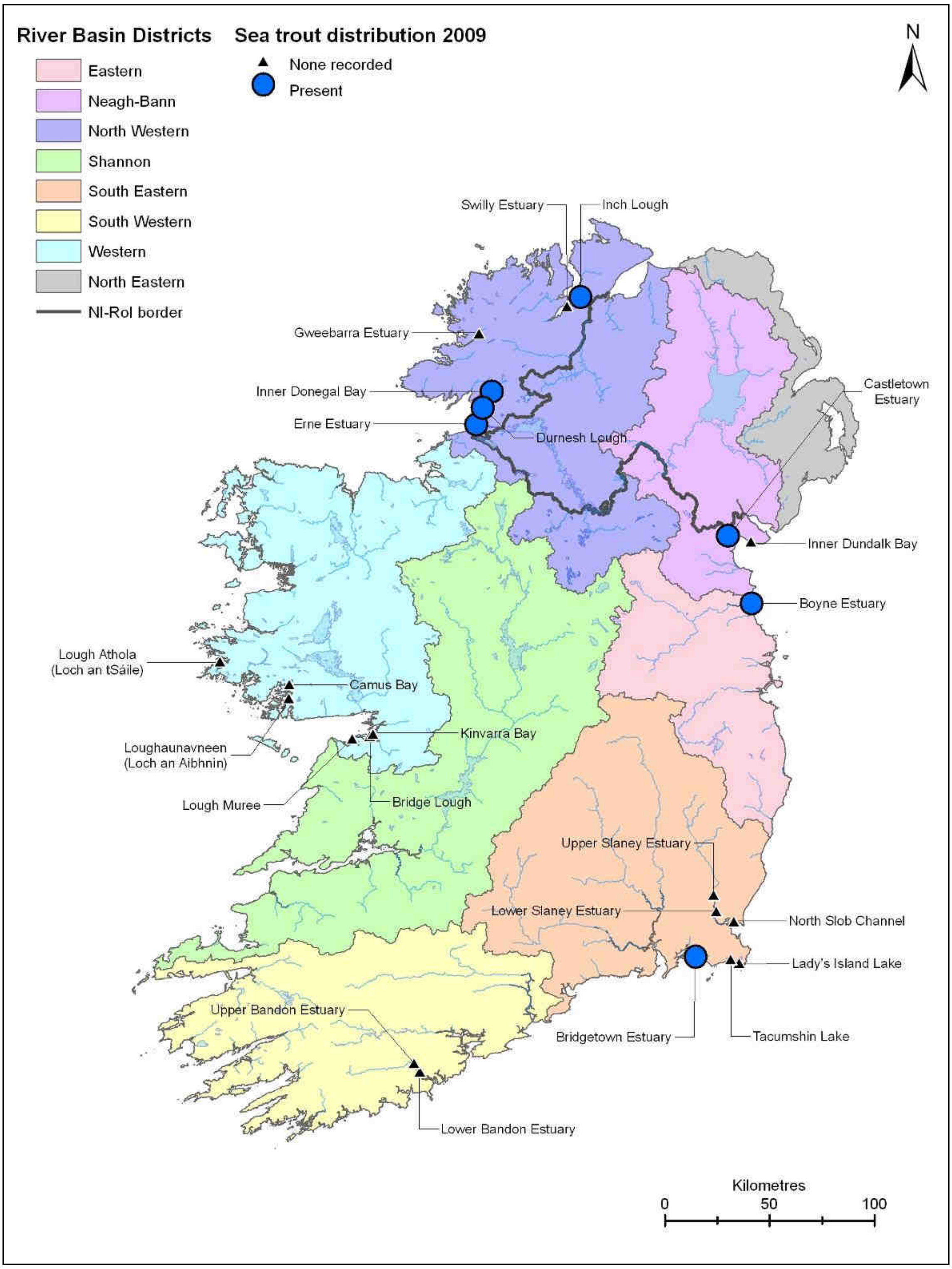

Fig 4.89. Sea trout distribution in transitional waters surveyed for WFD fish monitoring, 2009

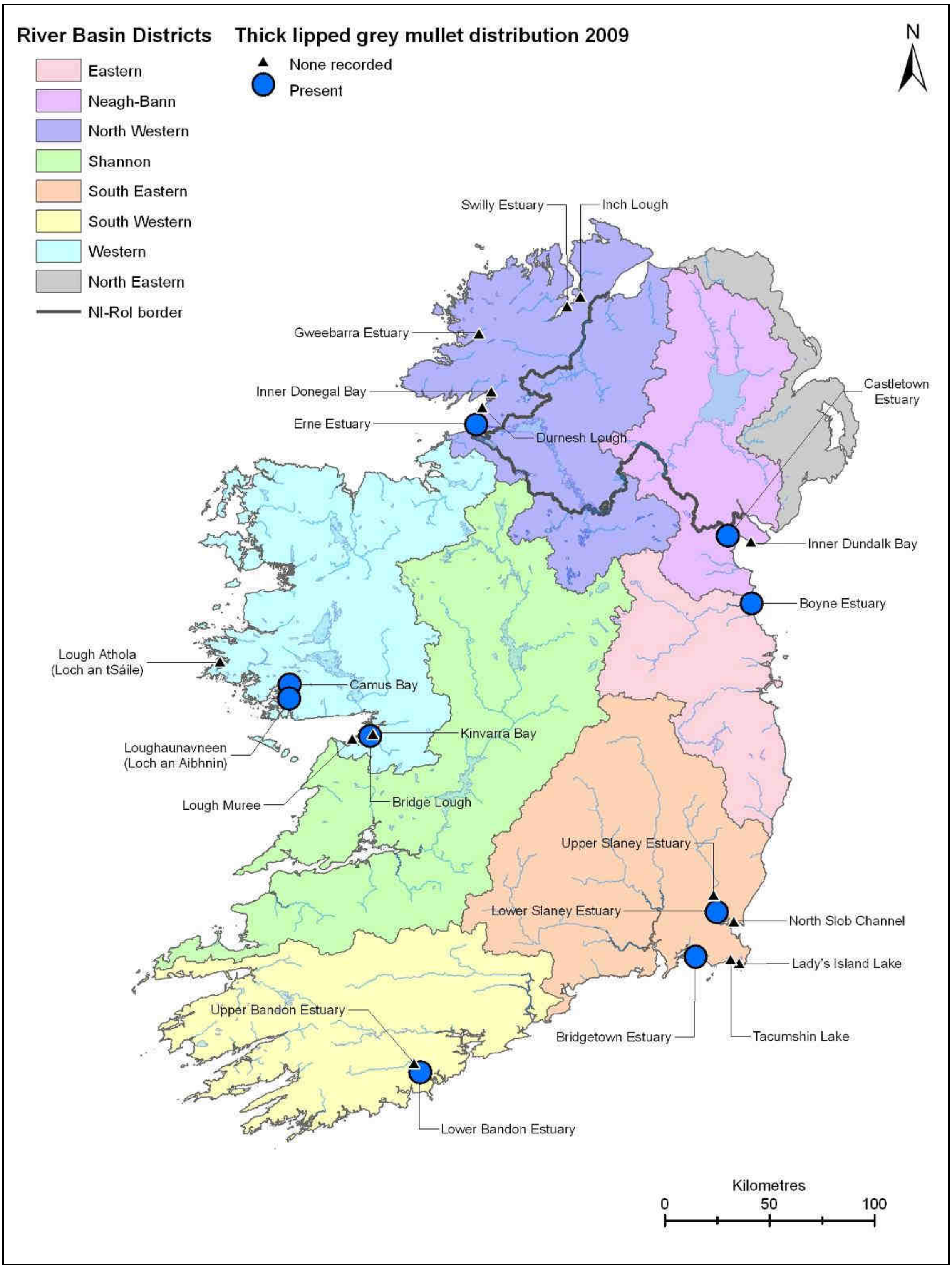

Fig 4.90. Thick-lipped grey mullet distribution in transitional waters surveyed for WFD fish monitoring, 2009

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. The CFB has completed fish surveys in 68 transitional waters to date. 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 in the UK (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). A total of 10 metrics are used in the TFCI. 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; however, at this stage it has been used, with expert opinion, to provide draft ecological status classifications for each transitional water body.

Out of the 23 transitional water bodies surveyed in 2009, 12 were identified as Transitional water body types (Table 4.11). Using the TFCI and expert opinion, one was classified as "High", nine were classified as "Good" and two were classified as "Moderate" (Fig. 4.91).

Eleven water bodies were identified as Lagoon/Freshwater Tidal water body types (Table 4.11). Using the TFCI and expert opinion, two were classified as "Good", seven were classified as "Moderate", one was classified as "Poor" and one was classified as "Bad" (Fig. 4.92).

Table 4.11. Draft Ecological Status Classification of transitional water bodies surveyed for fish during 2009 using the Transitional Fish Classification Index (TFCI)

Water body	Type	Ecological Status
Bandon Estuary, Lower	TW	High
Boyne Estuary	TW	Good
Bridgetown Estuary	TW	Good
Camus Bay	TW	Good
Donegal Bay Inner	TW	Good
Gweebarra Estuary	TW	Good
Kinvarra Bay	TW	Good
Slaney Estuary, Lower	TW	Good
Swilly Estuary	TW	Good
Inch Lough	FT	Good
Erne Estuary	TW	Good
Athola, Lough (Loch an tSaile)	L	Good
Castletown Estuary	TW	Moderate
Dundalk Bay, Inner	TW	Moderate
Bandon Estuary, Upper	FT	Moderate
Durnesh Lough	L	Moderate
Lady’s Island Lake	L	Moderate
Loughaunavneen (Loch an Aibhnin)	L	Moderate
North Slob Channel	L	Moderate
Slaney Estuary, Upper	FT	Moderate
Tacumshin Lake	L	Moderate
Bridge Lough	L	Poor
Muree, Lough	L	Bad

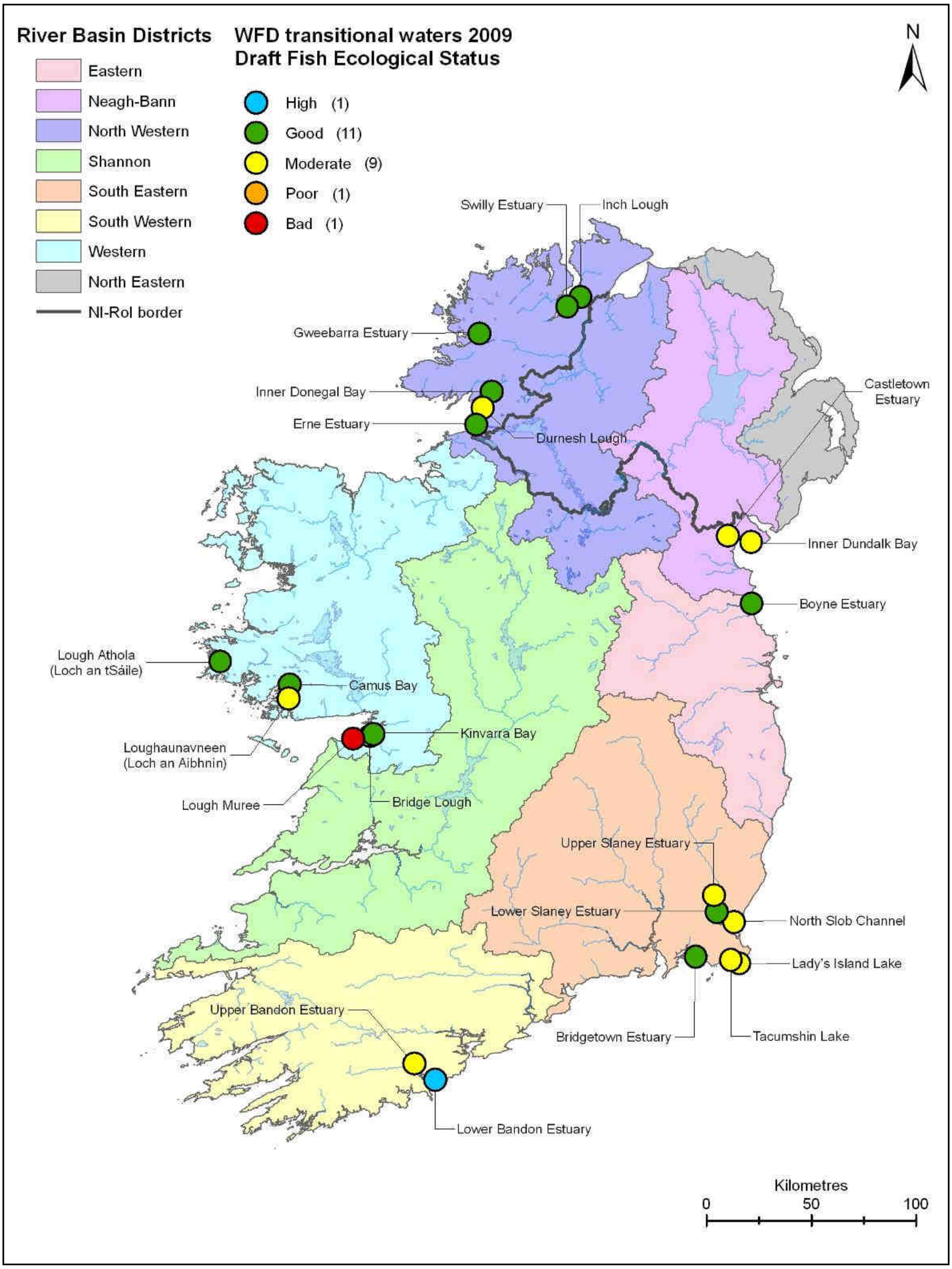

Fig. 4.91 Draft Ecological Status Classification of transitional water bodies surveyed for fish during 2009 using the Transitional Fish Classification Index (TFCI)

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 fifteen fish species (sea trout are included as a separate 'variety' of trout) were recorded in the 23 lakes surveyed during the 2009 WFD surveillance monitoring season. Roach x bream hybrids were also recorded. This is four fewer species than were captured in the 2008 season (Kelly *et al*., 2009); however, this is most likely due to the geographical variation in survey locations. Eels, followed by brown trout and pike were the three most widely distributed species recorded. The maximum number of fish species recorded in any one lake was eight (Lough Arrow, WRBD), with a mixture of native and non-native fish species being captured in this lake.

Sixteen fish species (sea trout are included as a separate 'variety' of trout) were recorded in the 52 river sites surveyed during the 2009 WFD surveillance monitoring season. Roach x bream hybrids were also recorded. This is similar to the 2008 monitoring season, in which 15 fish species (including sea trout) and roach x bream hybrids were recorded (Kelly *et al*., 2009). Brown trout, salmon and eels were the most widely distributed fish species recorded. The highest number of fish species (including hybrids) recorded at any one site was twelve (River Barrow, SERBD), again due to the presence of a mixture of native and non-native fish species.

A total of 56 fish species were recorded in the 23 transitional waters surveyed during the 2009 WFD surveillance monitoring season. This is compared to 61 species recorded during 2008 (Kelly *et al*., 2009). European eel, flounder, sand goby and 3-spined stickleback were the most widely distributed fish species, being found in over 70% of the sites surveyed. The maximum number of fish species recorded in any one water body was 32 (Lough Swilly, NWRBD).

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 2009 surveillance monitoring programme for rivers, in which 96% of rivers surveyed contained brown trout. Brown trout were also recorded in 69.6% of lakes surveyed, mainly being absent in lakes where non-native fish dominated the population. 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).

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 100% of lakes and 83% of river sites. Salmon were recorded in 79% of river sites, but only 4.3% 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. 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., CFB, *pers*. *comm*.).

Char were recorded in four lakes during 2009 (Kindrum Lough, Lough Sessiagh, Doo Lough and Lough Mask). Although historically present in Lough Dan and Lough Tay, no char specimens were captured in 2009 (or in previous surveys since the 1990's), suggesting the likely local extinction of the species from these lakes. 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 effect 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 be achieved by 2015, i.e. to preserve, protect and restore the quality of the aquatic environment. The absence of these native species within particular catchments must be addressed in the Draft River Basin Management Plans. 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, 2008).

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, accidentally or 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 16 out of the 23 lakes surveyed during 2009. Overall, the majority of moderate and high alkalinity lakes (in parts of the midlands and the west) recorded higher species richness than low alkalinity lakes, reflecting the presence of non-native species in these lakes. Non-native species were present in 38 out of the 52 river sites surveyed. Rivers located in the north-east of the country generally tended to have a higher species richness than those located elsewhere, due to the presence of non-native species. However, it must be noted that a low number of sites were sampled in the northern end of the ShIRBD during 2009, which is generally also rich in non-native fish species (Kelly *et al*., 2009). Non-native species were also present in five of the 23 transitional water bodies surveyed.

Pike, perch and roach are three of the most common non-native fish species recorded in Irish waters. In 2009, these species were recorded in a cluster of lakes mainly in counties Clare, Monaghan and Mayo and throughout the ShIRBD, whilst they were present in river sites mainly in the ShIRBD and interconnecting parts of the northern region linked via the Shannon-Erne Waterway. 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 2009 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, River Nanny, Lough Arrow, Lough Cullin, Lough Carra and Lough Mask), providing evidence that these fish have been deliberately relocated in the past to new catchments over the past 50 years. The Munster Blackwater is the first river site in Ireland in which roach were recorded. Non-native fish recorded in the transitional water surveys were freshwater species, e.g. rudd and roach, 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 to. 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 national policy of Inland Fisheries Ireland (IFI) is to preserve 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 six lakes surveyed during 2009 (Lough Bunny, Dromore Lough, Lough Alewnaghta, Inchicronan Lough, White Lough and Lough Muckno). In waters where brown trout, cyprinds 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 seven out of 23 lakes surveyed during 2009, and nine out of the 52 river sites surveyed (mostly in the north-east). Roach, introduced to Ireland in 1889 (Went, 1950), have been distributed to many waters, mostly by anglers (Fitzmaurice, 1981), over the last 40 years. Roach is a species which has been shown to affect salmonid production and cause the decline of brown trout fishing (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 were recorded during four river surveys in the SERBD and SWRBD. Introduced along with roach to the Munster Blackwater in 1889 (Went, 1950), dace 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 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 2009 WFD surveillance monitoring surveys, dace were recorded in both the River Barrow and one of its tributaries, the Tully Stream.

Water bodies with non-native 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

Age analysis 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.

It has been demonstrated that, in lakes, alkalinity influences the growth of brown trout (Fig. 4.41), roach (Fig 4.42) and perch (Fig 4.43), with faster growths being evident in higher alkalinity lakes for all three species. Similarly, brown trout in rivers display the same growth patterns, with faster growth in higher alkalinity rivers (Fig. 4.79).

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

It has been demonstrated in this report that alkalinity also has 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 the 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).

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 where 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 inhabitat 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 (FIL) was developed during the NS SHARE "Fish in Lakes" Project. This tool is 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 is 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 non-native species. Of the 23 lake water bodies surveyed during 2009, two lakes were assigned a draft classification of High, eight were classified as Good, 12 were classified as Moderate, one was classified as Poor and none were classified as 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 (mainly percids and cyprinids) associated with lowland lakes subject to more intensive anthropogenic pressures. Six lakes classified in 2005 and 2006 were again assigned status in 2009. The ecological status remained the same for all lakes apart from White Lough where the status improved from Poor in 2006 to Moderate in 2009 (Kelly *et al*., 2008b). Lough Muckno changed from being a roach dominant lake in 2006 to a perch dominant lake in 2009, whilst Lough Sessiagh changed from being a char dominant lake in 2006 to a brown trout dominant lake in 2009 (Kelly *et al*., 2007a); however, these changes have not affected their ecological status classifications. Nevertheless, there is concern over the reduction in char numbers in Lough Sessiagh and it is suggested that the population should be monitored closely to prevent any further deterioration of this vulnerable and red listed species. The main pressures affecting the population should be identified as an urgent priority and measures put in place to mitigate their impact. One such pressure already identified is the increase in total phosphorous levels in the lake with a resultant change in trophic status classification from oligotrophic in 2006 to mesotrophic in 2009.

The "Fish in Lakes" ecological classification tool is currently being further developed 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. This new classification tool will be intercalibrated with other European Member States during 2010 and 2011, and used to assign lakes to ecological status classes in the future.

No fish classification method currently exists in Ireland for classifying river water quality based on fish populations. Currently, ecological status classifications are based on expert opinion using research undertaken during a project to investigate the relationship between fish stocks, ecological quality ratings (Q-values), environmental factors and degree of eutrophication (Kelly *et al*., 2007c). An ecological classification tool, however, is being 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 to be used in the model, which is being developed under the management of the Scotland & Northern Ireland Forum for Environmental Research (SNIFFER). 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 (FCS2) be used. This scheme 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 proposed method will provide an Ecological Quality Ratio (EQR) between 1 and 0. Five class boundaries will be defined along this range, to correspond with the five ecological status classes of High, Good, Moderate, Poor and Bad.

Confidence levels will then be assigned to each class and represented as probabilities. Work on the rivers classification tool is still ongoing and is due for completion in mid-2010. Once completed, the ecological classification tool for fish in rivers will be intercalibrated with other European Member States and will be used for the classification of rivers ecological status in the future.

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 CFB 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 23 transitional water bodies surveyed in 2009, 10 (43%) were assigned a draft ecological classification of either High (one water body) or Good (9 water bodies) status, while 13 (57%) were classified as less than Good status (11 Moderate, 1 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 a 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 2009

Lake	3-sp stickleback	Sea trout	Char	Salmon	Brown trout	Eel	Minnow	Perch	Pike	Rainbow trout	Roach	Bream	Gudgeon	Tench	Rudd	Roach x Bream
Alewnaghta						X		X	X		X					X
Anure					X	X	X									
Arrow	X				X	X		X	X		X	X			X	
Bunny						X		X	X						X	
Cam					X	X				X						
Carra	X				X	X		X	X							
Cullaun					X	X		X	X						X	
Cullin					X	X		X	X		X			X		
Dan					X	X										
Derg					X	X		X	X		X	X		X		X
Doo	X	X	X	X	X	X										
Dromore						X		X	X						X	
Dungloe		X			X	X										
Gur						X			X						X	
Inchicronan						X		X	X						X	
Kindrum	X		X		X	X										
Mask			X		X	X		X	X		X	X				
Muckanagh					X	X		X	X					X	X	
Muckno						X		X	X		X	X	X			X
Nasnahida					X	X										
Sessiagh	X		X		X	X										
Tay					X	X										
White						X		X	X		X	X				X

APPENDIX 3

Summary of the growth of brown trout in 16 lakes in the 2009 SM area (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	Growth Category
Muckanagh	Mean	6.1	12.0					
	n	2	2					
	S.D.	1.2	2.5					
	S.E.	0.9	1.8					
	Min.	5.2	10.3					
	Max.	6.9	13.8					
Derg	Mean	7.4	15.2	28.6	38.2	43.2		Very fast
	n	24	19	6	3	2		
	S.D.	1.5	3.2	3.5	2.9	3.6		
	S.E.	0.3	0.7	1.4	1.7	2.5		
	Min.	4.6	9.5	22.2	35.3	40.6		
	Max.	9.8	22.6	31.6	41.1	45.7		
Arrow	Mean	7.9	15.9	28.5	43.4	52.1		Very fast
	n	14	6	5	3	2		
	S.D.	1.6	3.3	4.9	3.8	7.1		
	S.E.	0.4	1.4	2.2	2.2	5.0		
	Min.	5.7	11.3	22.1	40.5	47.1		
	Max.	10.1	19.2	34.5	47.7	57.1		
Kindrum	Mean	7.2	20.0	25.8	29.2			Slow
	n	62	55	20	5			
	S.D.	1.5	3.9	3.6	2.2			
	S.E.	0.2	0.5	0.8	1.0			
	Min.	4.6	11	20.4	26.8			
	Max.	10.8	25.6	34.8	32.6			
Sessiagh	Mean	7.8	17.5	27.1	33.3	37.1		Fast
	n	31	24	16	5	2		
	S.D.	1.8	5.1	2.5	3.3	3.4		
	S.E.	0.3	1.0	0.6	1.5	2.4		
	Min.	4.5	9	23.8	29.5	34.7		
	Max.	11.2	25.4	31.8	37.5	39.5		
Dungloe	Mean	6.5	14.1					
	n	24	11					
	S.D.	1.3	1.7					
	S.E.	0.3	0.5					
	Min.	3.1	11.5					
	Max.	8.7	17.1					

APPENDIX 3 continued

Summary of the growth of brown trout in 16 lakes in the 2009 SM area (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	Growth Category
Doo	Mean	6.8	13.7	19.3				
	n	30	9	5				
	S.D.	1	1.3	2.2				
	S.E.	0.2	0.4	1.0				
	Min.	4.7	11.9	17.2				
	Max.	9.3	16	22.9				
Nasnahida	Mean	6.5	13.5	17.9				
	n	57	39	15				
	S.D.	1.5	1.9	1.3				
	S.E.	0.2	0.3	0.3				
	Min.	3.3	9.3	15.8				
	Max.	10.7	16.9	20.7				
Anure	Mean	5.7	12.6	18.3	22.2	25.9		Very slow
	n	56	43	27	8	1		
	S.D.	1.3	2.6	2.6	2.1	n/a		
	S.E.	0.2	0.4	0.5	0.8	n/a		
	Min.	3.7	7.9	13.9	19.9	25.9		
	Max.	8.6	19.4	23.5	27.1	25.9		
Tay	Mean	5.3	12.2	18.2	21.6			Very slow
	n	86	74	32	2			
	S.D.	1.1	1.9	2.2	1.8			
	S.E.	0.1	0.2	0.4	1.3			
	Min.	3.3	7.4	12.7	20.3			
	Max.	8.8	19.1	24.2	22.9			
Cullin	Mean	8.2	16.9	26.4	31.4	44.1	49.8	Fast
	n	13	11	4	1	1	1	
	S.D.	1.8	2.7	2.8	n/a	n/a	n/a	
	S.E.	0.5	0.8	1.4	n/a	n/a	n/a	
	Min.	4.2	13.3	24.1	31.4	44.1	49.8	
	Max.	10.6	22	30.2	31.4	44.1	49.8	
Carra	Mean	6.9	19.1	31.9	40	42	45.4	Very fast
	n	33	28	16	9	4	4	
	S.D.	1.4	3.6	4.4	5.1	2.4	2.5	
	S.E.	0.2	0.7	1.1	1.7	1.2	1.3	
	Min.	4.4	12.2	22.4	33.4	40.1	42.8	
	Max.	9.3	25.2	38.5	48.7	45.1	47.8	

APPENDIX 3 continued

Summary of the growth of brown trout in 16 lakes in the 2009 SM area (L1=back calculated length of trout at the end of the first winter etc.)

Lake		L1	L2	L3	L4	L5	L6	Growth Category
Caum	Mean	6.0	13.2	18.2	21.9			Very slow
	n	53	47	32	2			
	S.D.	1.3	1.9	2.0	1.0			
	S.E.	0.2	0.3	0.4	0.7			
	Min.	3.5	8.3	13.3	21.2			
	Max.	9.5	16.7	22	22.7			
Dan	Mean	5.4	13	18.7	21.8	25.6		Very slow
	n	198	169	92	23	2		
	S.D.	1.1	2	1.9	2.4	1.5		
	S.E.	0.1	0.2	0.2	0.5	1.0		
	Min.	3.1	8.5	13.7	18.7	24.6		
	Max.	8.2	18.8	25.2	28.8	26.6		
Cullaun	Mean	5.5	11	21.7				
	n	1	1	1				
	S.D.	n/a	n/a	n/a				
	S.E.	n/a	n/a	n/a				
	Min.	5.5	11	21.7				
	Max.	5.5	11	21.7				
Mask	Mean	7.3	18.4	29.4	39.9	46.1	50.6	Very fast
	n	38	26	18	13	7	2	
	S.D.	1.8	4.5	6.4	6.9	8.8	3.4	
	S.E.	0.3	0.9	1.5	1.9	3.3	2.4	
	Min.	4.0	12.8	20.1	32.2	36.5	48.2	
	Max.	11.6	27.8	42.9	56.1	63.1	53.0	

APPENDIX 4

Summary of the growth of perch in 13 lakes in the 2009 SM area (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
Inchicronan	Mean	6.8	12.2	16.6	20.0	20.7						
	n	97	72	29	8	1						
	S.D.	1.3	1.8	1.6	1.2	n/a						
	S.E.	0.1	0.2	0.3	0.4	n/a						
	Min.	4.7	8.0	13.0	18.6	20.7						
	Max.	9.9	17.0	20.3	21.9	20.7						
Muckanagh	Mean	6.1										
	n	3										
	S.D.	0.4										
	S.E.	0.3										
	Min.	5.8										
	Max.	6.6										
Arrow	Mean	5.9	11.1	15.5	19.3	22.2	23.9	24.4	26.8	27.8		
	n	114	91	61	41	32	19	4	3	2		
	S.D.	1.0	2.0	2.2	2.1	1.6	1.6	2.1	2.5	3.4		
	S.E.	0.1	0.2	0.3	0.3	0.3	0.4	1.1	1.4	2.4		
	Min.	3.5	6.9	10.8	14.1	18.8	21.0	22.6	24.6	25.4		
	Max.	8.2	16.3	19.7	24.7	24.8	26.2	26.9	29.5	30.2		
Bunny	Mean	7.2	14.6	20.8	25.1							
	n	36	33	25	3							
	S.D.	0.9	2.2	2.5	0.6							
	S.E.	0.2	0.4	0.5	0.3							
	Min.	5.5	10.5	16.3	24.7							
	Max.	9.0	19.0	24.0	25.8							
Cullin	Mean	6.4	10.8	16.4	18.3	21.0	22.8	24.0	27.1	28.2		
	n	21	9	4	2	1	1	1	1	1		
	S.D.	1.2	1.8	1.6	0.7	n/a	n/a	n/a	n/a	n/a		
	S.E.	0.3	0.6	0.8	0.5	n/a	n/a	n/a	n/a	n/a		
	Min.	4.5	8.4	14.8	17.8	21.0	22.8	24.0	27.1	28.2		
	Max.	8.8	13.6	18.6	18.7	21.0	22.8	24.0	27.1	28.2		
Carra	Mean	6.3	12.6	18.7	24.0	27.1	27.0	33.8				
	n	120	108	80	38	14	5	1				
	S.D.	1.1	1.8	3.1	4.0	4.5	3.1	n/a				
	S.E.	0.1	0.2	0.3	0.7	1.2	1.4	n/a				
	Min.	4.4	8.0	10.6	15.6	21.4	23.3	33.8				
	Max.	9.4	16.8	25.2	29.5	32.5	31.7	33.8				
Mask	Mean	5.7	10.6	15.5	18.9	21.2	23.3	26.2	31.2	33.6	35.2	
	n	154	135	104	79	49	24	8	4	4	1	
	S.D.	1.0	1.4	2.0	2.3	2.5	3.1	4.4	4.3	4.3	n/a	
	S.E.	0.1	0.1	0.2	0.3	0.4	0.6	1.6	2.1	2.2	n/a	
	Min.	4.0	6.8	10.3	12.7	15.7	17.7	19.2	27.4	28.8	35.2	
	Max.	9.0	15.2	19.3	22.7	26.5	31.2	34.4	37.2	39.3	35.2	

APPENDIX 4 continued

Summary of the growth of perch in 13 lakes in the 2009 SM area (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
Dromore	Mean	7.1	12.2	16.3	19.0	22.1						
	n	83	68	49	21	12						
	S.D.	0.9	1.2	1.8	1.7	2.0						
	S.E.	0.1	0.2	0.3	0.4	0.6						
	Min.	5.0	9.6	12.9	16.8	18.1						
	Max.	9.9	15.5	20.9	22.4	25.1						
White	Mean	5.7	9.6	15.0								
	n	70	26	7								
	S.D.	0.5	0.9	1.5								
	S.E.	0.1	0.2	0.6								
	Min.	4.5	8.1	12.9								
	Max.	6.9	12.2	16.9								
Cullaun	Mean	7.0	13.5	17.9	21.0	22.4						
	n	36	33	10	4	1						
	S.D.	1.0	1.5	1.3	0.5	n/a						
	S.E.	0.2	0.3	0.4	0.3	n/a						
	Min.	5.1	10.1	15.2	20.3	22.4						
	Max.	9.0	16.3	19.4	21.5	22.4						
Alewnaghta	Mean	5.7	10.1	16.4	19.8	21.9						
	n	78	54	20	10	1						
	S.D.	0.8	1.3	2.4	1.8	n/a						
	S.E.	0.1	0.2	0.5	0.6	n/a						
	Min.	3.6	7.8	10.9	17.1	21.9						
	Max.	7.5	13.4	20.0	22.5	21.9						
Muckno	Mean	5.4	10.6	14.8	17.8	21.1	24.7	25.6				
	n	118	96	65	29	23	4	1				
	S.D.	0.7	1.5	2.1	2.1	2.7	1.2	n/a				
	S.E.	0.1	0.2	0.3	0.4	0.6	0.6	n/a				
	Min.	3.8	6.6	10.5	14.5	16.5	23.1	25.6				
	Max.	7.1	13.8	18.9	22.8	27.2	25.8	25.6				
Derg	Mean	6.0	11.8	17.2	20.8	22.7	21.9	21.7	23.9	26.2	28.4	30.4
	n	205	155	125	63	39	8	4	4	3	2	1
	S.D.	0.8	1.4	1.9	2.0	2.2	2.1	0.9	1.2	1.7	2.1	n/a
	S.E.	0.1	0.1	0.2	0.3	0.3	0.7	0.4	0.6	1.0	1.5	n/a
	Min.	4.1	8.3	9.8	13.8	17.0	19.2	20.9	22.9	24.9	26.9	30.4
	Max.	8.3	15.7	21.2	24.4	27.1	24.6	22.8	25.5	28.1	29.9	30.4

APPENDIX 5

Summary of the growth of roach in 6 lakes in the 2009 SM area (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
White Lake	Mean	3.5	7.5	11.7	15.6	18.1	20.0	21.2	22.5	24.4					
	n	57	57	53	12	5	3	1	1	1					
	S.D.	0.5	1.0	1.2	0.9	1.2	0.6	n/a	n/a	n/a					
	S.E	0.1	0.1	0.2	0.3	0.6	0.4	n/a	n/a	n/a					
	Min.	2.5	5.2	9.0	14.4	16.6	19.3	21.2	22.5	24.4					
	Max.	5.3	9.9	14.5	17.3	19.6	20.6	21.2	22.5	24.4					
Alewnaghta	Mean	3.7	8.3	13.1	18.1	20.7	22.0	24.9	26.7	28.7	30.1	31.9	33.5		
	n	33	30	7	5	4	3	3	3	3	3	2	1		
	S.D.	0.6	0.9	1.5	1.3	1.5	1.6	1.7	2.1	2.1	1.5	1.3	n/a		
	S.E.	0.1	0.2	0.6	0.6	0.7	0.9	1.0	1.2	1.2	0.9	0.9	n/a		
	Min.	2.7	6.6	11.0	17.0	19.1	20.4	23.4	25.1	26.8	28.7	31.0	33.5		
	Max.	4.9	10.5	15.8	20.3	22.6	23.6	26.8	29.1	30.9	31.6	32.8	33.5		
Muckno	Mean	3.2	7.4	11.3	14.4	16.9	19.0	19.8	22.1	23.2	24.2	25.1			
	n	51	44	36	23	20	14	5	3	3	2	2			
	S.D.	0.6	1.4	1.8	1.8	1.8	1.4	1.7	1.5	1.4	0.5	0.5			
	S.E.	0.1	0.2	0.3	0.4	0.4	0.4	0.8	0.9	0.8	0.4	0.4			
	Min.	1.9	4.5	7.6	10.8	13.3	17.1	18.7	20.9	21.9	23.8	24.7			
	Max.	4.6	10.4	14.5	17.5	18.9	21.6	22.8	23.8	24.7	24.5	25.5			
Derg	Mean	3.5	8.2	13.0	17.4	21.0	24.1	25.9	27.0	28.3	29.7	30.4	31.2	33.2	34.2
	n	91	86	84	64	49	40	24	13	9	7	5	2	1	1
	S.D.	0.6	1.3	2.1	2.5	2.0	1.8	2.0	1.6	1.5	1.7	1.2	1.4	n/a	n/a
	S.E.	0.1	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.5	1.0	n/a	n/a
	Min.	2.3	5.3	8.6	11.1	15.1	20.1	21.8	24.1	26.4	27.7	29.0	30.2	33.2	34.2
	Max.	4.9	11.2	18.3	22.4	24.5	27.3	29.7	29.9	30.2	31.9	32.0	32.2	33.2	34.2
Cullin	Mean	3.4	7.7	12.7	17.3	19.8	21.9	23.7	26.4	27.4					
	n	118	117	100	76	68	50	25	8	2					
	S.D.	0.5	1.3	2.0	2.3	2.3	2.1	2.3	2.1	3.1					
	S.E.	0.0	0.1	0.2	0.3	0.3	0.3	0.5	0.7	2.2					
	Min.	2.2	4.7	7.0	12.3	14.7	17.7	20.0	23.0	25.1					
	Max.	5.3	10.8	17.6	22.9	24.7	26.9	28.3	29.2	29.6					
Mask	Mean	3.4	8.2	14.3	18.7	22.4	25.5	27.8	29.8	30.8	30.6				
	n	128	121	120	79	65	61	48	35	8	3				
	S.D.	0.8	1.6	2.6	2.8	2.8	2.4	2.1	1.8	2.7	3.0				
	S.E.	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	1.0	1.7				
	Min.	2.0	4.1	7.3	12.3	14.7	16.9	20.3	23.7	25.4	27.1				
	Max.	5.4	11.9	19.7	24.4	27.4	28.9	30.9	32.0	34.0	32.5				

APPENDIX 6

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Argideen	Mean	5.8	15.2					Slow
	S.D.	2.9	5.2					
	S.E.	1.5	3.7					
	n	4	2					
	Min.	3.4	11.5					
	Max.	10.0	18.9					
Athboy	Mean	7.4	14.6					Slow
	S.D.	1.7	2.3					
	S.E.	0.3	0.7					
	n	38	13					
	Min.	3.8	9.4					
	Max.	10.7	17.0					
Awbeg	Mean	7.9	14.6	21.5	31.7			Slow
	S.D.	1.3	3.0	2.7	n/a			
	S.E.	0.2	0.6	1.1	n/a			
	n	37	25	6	1			
	Min.	5.5	9.8	17.5	31.7			
	Max.	11.1	22.7	24.7	31.7			
Ballyfinboy	Mean	8.0	15.3					Slow
	S.D.	1.7	4.4					
	S.E.	0.8	3.1					
	n	5	2					
	Min.	6.3	12.2					
	Max.	10.6	18.4					
Barrow	Mean	10.6	18.3	19.4				Fast
	S.D.	5.2	8.4	n/a				
	S.E.	1.7	3.2	n/a				
	n	9	7	1				
	Min.	4.6	9.6	19.4				
	Max.	19.3	34.4	19.4				
Big	Mean	5.3	9.9	13.2				Very slow
	S.D.	0.6	0.8	n/a				
	S.E.	0.1	0.2	n/a				
	n	33	14	1				
	Min.	4.0	8.9	13.2				
	Max.	6.3	12.1	13.2				
Bilboa	Mean	6.6	14.2					Slow
	S.D.	1.2	2.5					
	S.E.	0.2	0.9					
	n	30	8					
	Min.	4.9	10.7					
	Max.	9.1	17.1					

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Black	Mean	7.9	20.2					Very fast
	S.D.	1.7	n/a					
	S.E.	0.3	n/a					
	n	28	1					
	Min.	4.3	20.2					
	Max.	11.5	20.2					
Blackwater (Kells)	Mean	7.3	9.9					Very slow
	S.D.	1.9	n/a					
	S.E.	0.3	n/a					
	n	29	1					
	Min.	4.7	9.9					
	Max.	11.3	9.9					
Blackwater (Killavullen)	Mean	6.9	14.7	21.0	22.3	29.5	34.2	Slow
	S.D.	1.8	3.7	3.0	n/a	n/a	n/a	
	S.E.	0.3	0.7	0.9	n/a	n/a	n/a	
	n	38	32	12	1	1	1	
	Min.	3.7	8.7	16.4	22.3	29.5	34.2	
	Max.	11.3	20.3	25.9	22.3	29.5	34.2	
Blackwater (Nohaval)	Mean	7.3	15.3	20.2	25.1			Slow
	S.D.	1.7	2.6	2.3	n/a			
	S.E.	0.3	0.6	1.0	n/a			
	n	41	23	5	1			
	Min.	4.3	11.1	16.4	25.1			
	Max.	10.9	23.4	22.0	25.1			
Boyne (Boyne Br.)	Mean	7.9	16.8	20.6				Fast
	S.D.	1.3	2.0	8.4				
	S.E.	0.2	0.4	3.2				
	n	40	24	7				
	Min.	5.6	12.4	2.1				
	Max.	10.9	20.8	26.5				

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Burren	Mean	7.6	12.4	17.0				Very slow
	S.D.	1.9	2.6	2.1				
	S.E.	0.3	0.6	1.5				
	n	31	18	2				
	Min.	3.4	9.1	15.6				
	Max.	11.9	20.2	18.5				
Bride	Mean	7.7	16.9	22.6				Fast
	S.D.	1.4	2.5	2.8				
	S.E.	0.2	0.5	2.0				
	n	46	22	2				
	Min.	4.9	12.5	20.6				
	Max.	10.6	23.0	24.6				
Clady	Mean	6.0	13.1	17.8				Slow
	S.D.	1.3	2.2	3.1				
	S.E.	0.3	0.8					
	n	16	8	3				
	Min.	4.0	9.6	14.7				
	Max.	8.2	16.1	20.9				
Creegh	Mean	8.2	14.5	19.1	22.8			Slow
	S.D.	1.1	1.9	1.7	n/a			
	S.E.	0.2	0.4	0.5	n/a			
	n	39	25	12	1			
	Min.	6.3	10.4	16.2	22.8			
	Max.	10.4	17.5	22.8	22.8			
Caher	Mean	8.8						n/a
	S.D.	1.2						
	S.E.	0.2						
	n	24						
	Min.	6.8						
	Max.	11.5						
Dargle	Mean	7.1	14.3					Slow
	S.D.	1.1	0.8					
	S.E.	0.3	0.6					
	n	12	2					
	Min.	4.8	13.7					
	Max.	8.6	14.8					
Dead	Mean	8.2	18.2	23.7				Fast
	S.D.	1.4	2.4	2.7				
	S.E.	0.3	0.5	1.2				
	n	31	23	5				
	Min.	4.5	11.6	20.8				
	Max.	10.7	22.8	27.6				

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Dee	Mean	9.0	19.4					Fast
	S.D.	1.3	3.0					
	S.E.	0.3	1.1					
	n	23	8					
	Min.	6.4	13.8					
	Max.	12.0	22.0					
Dinin	Mean	6.8	16.6	18.9				Slow
	S.D.	1.4	2.7	n/a				
	S.E.	0.2	0.5	n/a				
	n	33	24	1				
	Min.	4.1	10.4	18.9				
	Max.	9.7	20.4	18.9				
Dunneill	Mean	7.1	14.3					Slow
	S.D.	1.3	2.1					
	S.E.	0.3	1.5					
	n	17	2					
	Min.	4.2	12.8					
	Max.	9.9	15.8					
Fergus	Mean	8.0	22.1					Very fast
	S.D.	0.7	3.1					
	S.E.	0.1	1.8					
	n	31	3					
	Min.	7.1	20.1					
	Max.	10.1	25.6					
Finn	Mean	8.8	16.4					Fast
	S.D.	2	4					
	S.E.	0.4	1.9					
	n	28.0	5.0					
	Min.	5.6	11.6					
	Max.	12.9	22.1					
Funshion	Mean	5.5	11.2	15.9				Very slow
	S.D.	1.1	1.7	n/a				
	S.E.	0.3	1.2	n/a				
	n	17	2	1				
	Min.	3.5	10.0	15.9				
	Max.	7.0	12.4	15.9				
Glencree	Mean	5.3	11.5	16.2	20.0			Very slow
	S.D.	0.6	1.3	0.7	2.0			
	S.E.	0.1	0.5	0.4	1.4			
	n	18	6	3	2			
	Min.	4.4	8.8	15.7	18.6			
	Max.	6.2	12.4	16.9	21.4			

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Glendine	Mean	7.2	13.5					Slow
	S.D.	0.8	0.9					
	S.E.	0.3	0.5					
	n	6	4					
	Min.	6.2	12.5					
	Max.	8.5	14.3					
Glenealo	Mean	5.8	9.1	14.9	18.2			Very slow
	S.D.	n/a	n/a	n/a	n/a			
	S.E.	n/a	n/a	n/a	n/a			
	n	1	1	1	1			
	Min.	5.8	9.1	14.9	18.2			
	Max.	5.8	9.1	14.9	18.2			
Gowlan	Mean	7.6	14.4	23.6				Slow
	S.D.	1.3	2.0	n/a				
	S.E.	0.3	1.0	n/a				
	n	20	4	1				
	Min.	4.7	12.7	23.6				
	Max.	9.7	16.2	23.6				
Greese	Mean	9.2	17.0					Fast
	S.D.	1.9	1.1					
	S.E.	0.5	0.5					
	n	15	5					
	Min.	6.0	15.4					
	Max.	11.6	18.5					
King's (Kilkenny)	Mean	7.1	14.4	18.6	21.4			Slow
	S.D.	1.2	2.3	1.9	2.1			
	S.E.	0.2	0.4	0.4	1.0			
	n	32	31	18	4			
	Min.	4.6	9.4	15.3	18.3			
	Max.	10.5	18.5	21.7	22.8			
Liffey (Ballyward Br.)	Mean	7.2	16.3	19.8				Slow
	S.D.	1.2	0.3	n/a				
	S.E.	0.5	0.2	n/a				
	n	5	3	1				
	Min.	5.6	16.0	19.8				
	Max.	8.8	16.6	19.8				
Liffey (Lucan)	Mean	9.5	20.5	29.8	36.3	42.7		Very fast
	S.D.	1.8	3.8	3.4	n/a	n/a		
	S.E.	0.3	0.9	1.5	n/a	n/a		
	n	36	17	5	1	1		
	Min.	4.4	12.7	24.5	36.3	42.7		
	Max.	13.4	29.7	33.3	36.3	42.7		

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Nanny (Meath)	Mean	9.4						n/a
	S.D.	0.4						
	S.E.	0.2						
	n	4						
	Min.	9.1						
	Max.	9.8						
Nanny (Tuam)	Mean	9.1	20.7	27.1	30.1	35.8		Fast
	S.D.	1.8	2.8	3.2	3.3	n/a		
	S.E.	0.2	0.4	0.9	1.9	n/a		
	n	60	42	12	3	1		
	Min.	5.6	13.2	20.8	26.4	35.8		
	Max.	13.6	27.3	31.1	32.6	35.8		
Nenagh	Mean	7.0	14.2	19.8	24.3			Slow
	S.D.	1.2	2.1	4.8	5.7			
	S.E.	0.2	0.4	1.5	4.0			
	n	53	27	11	2			
	Min.	4.8	9.5	14.9	20.3			
	Max.	10.0	17.3	32.3	28.3			
Newport	Mean	6.0	13.2	15.5				Slow
	S.D.	1.5	2.4	3.0				
	S.E.	0.4	0.6					
	n	15	14	4				
	Min.	4.2	9.3	12.5				
	Max.	8.9	17.5	18.6				
Owenbrin	Mean	4.4	8.0					Very slow
	S.D.	0.5	n/a					
	S.E.	0.2	n/a					
	n	6	1					
	Min.	3.8	8.0					
	Max.	5.0	8.0					
Owendalulleegh	Mean	8.6	16.0	25.1				Fast
	S.D.	1.7	3.2	n/a				
	S.E.	0.3	0.8	n/a				
	n	32	18	1				
	Min.	4.7	11.0	25.1				
	Max.	11.4	23.8	25.1				
Owvane	Mean	7.4						n/a
	S.D.	1.3						
	S.E.	0.3						
	n	20						
	Min.	4.6						
	Max.	10.0						

APPENDIX 6 continued

Summary of the growth of brown trout in 45 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2	L3	L4	L5	L6	Growth category
Owveg (Kerry)	Mean	6.7	16.1					Fast
	S.D.	1.4	n/a					
	S.E.	0.4	n/a					
	n	14	1					
	Min.	4.8	16.1					
	Max.	9.8	16.1					
Slaney	Mean	5.9	13.0	16.2	17.5	20.6		Very Slow
	S.D.	1.1	2.3	2.8	n/a	n/a		
	S.E.	0.2	0.5	1.3	n/a	n/a		
	n	34	20	5	1	1		
	Min.	3.9	8.2	12.9	17.5	20.6		
	Max.	8.4	16.3	20.4	17.5	20.6		
Tully Stream	Mean	7.3	16.6	23.5				Fast
	S.D.	2.5	4.8	4.9				
	S.E.	0.6	1.2	2.4				
	n	17	15	4				
	Min.	4.0	9.7	16.2				
	Max.	11.6	26.0	26.3				
Unshin	Mean	5.1	18.2					Fast
	S.D.	1.0	n/a					
	S.E.	0.4	n/a					
	n	6	1					
	Min.	4.0	18.2					
	Max.	6.4	18.2					
White (Louth)	Mean	7.4	13.9	23.9				Slow
	S.D.	1.8	3.6	3.2				
	S.E.	0.6	1.3	2.2				
	n	9	8	2				
	Min.	5.4	10.8	21.7				
	Max.	10.2	21.4	26.1				

APPENDIX 7

Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2
Argideen	Mean	4.5	7.6
	S.D.	1.0	n/a
	S.E.	0.2	n/a
	n	38	1
	Min.	3.5	7.6
	Max.	8.3	7.6
Athboy	Mean	5.6	
	S.D.	1.3	
	S.E.	0.3	
	n	21	
	Min.	3.6	
	Max.	9.6	
Awbeg	Mean	5.6	
	S.D.	0.7	
	S.E.	0.1	
	n	21	
	Min.	4.1	
	Max.	6.8	
Bandon	Mean	4.1	
	S.D.	0.6	
	S.E.	0.2	
	n	7	
	Min.	3.2	
	Max.	5.0	
Barrow	Mean	5.1	
	S.D.	0.6	
	S.E.	0.2	
	n	9	
	Min.	3.9	
	Max.	6.3	
Bilboa	Mean	4.5	8.6
	S.D.	1.0	1.0
	S.E.	0.1	0.3
	n	45	12
	Min.	2.7	7.2
	Max.	6.6	10.3
Black	Mean	5.1	9.7
	S.D.	0.6	0.5
	S.E.	0.1	0.3
	n	24	2
	Min.	4.1	9.3
	Max.	6.5	10.0

APPENDIX 7 continued

Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River	S.E.	L1	L2
Blackwater (Kells)	Mean	6.5	
	S.D.	0.5	
	S.E.	0.2	
	n	4	
	Min.	5.9	
	Max.	6.9	
Blackwater (killavullen Br.)	Mean	4.5	
	S.D.	1.4	
	S.E.	0.3	
	n	22	
	Min.	2.6	
	Max.	8.8	
Blackwater (Nohaval Br.)	Mean	4.6	
	S.D.	0.8	
	S.E.	0.2	
	n	12	
	Min.	3.7	
	Max.	6.5	
Bride	Mean	5.9	
	S.D.	0.8	
	S.E.	0.2	
	n	17	
	Min.	4.6	
	Max.	7.2	
Broadford	Mean	5.3	
	S.D.	0.4	
	S.E.	0.1	
	n	13	
	Min.	4.5	
	Max.	6.1	

APPENDIX 7 continued

Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River	S.E.	L1	L2
Burren	Mean	5.1	
	S.D.	0.9	
	S.E.	0.3	
	n	7	
	Min.	4.0	
	Max.	6.2	
Clady	Mean	4.2	7.9
	S.D.	1.0	0.5
	S.E.	0.2	0.2
	n	25	5
	Min.	2.7	7.3
	Max.	7.7	8.5
Creegh	Mean	5.9	9.1
	S.D.	0.9	0.8
	S.E.	0.2	0.5
	n	29	2
	Min.	4.4	8.6
	Max.	8.2	9.6
Dargle	Mean	4.9	
	S.D.	0.8	
	S.E.	0.2	
	n	22	
	Min.	3.5	
	Max.	6.2	
Dead	Mean	6.1	
	S.D.	1.1	
	S.E.	0.3	
	n	16	
	Min.	4.5	
	Max.	8.0	
Dee	Mean	5.1	
	S.D.	1.4	
	S.E.	0.7	
	n	4	
	Min.	3.7	
	Max.	7.0	
Dinin	Mean	5.1	
	S.D.	1.2	
	S.E.	0.3	
	n	17	
	Min.	3.4	
	Max.	7.4	

APPENDIX 7 continued

Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River		L1	L2
Funshion	Mean	5.2	10.0
	S.D.	1.4	1.3
	S.E.	0.3	0.9
	n	18	2
	Min.	3.7	9.1
	Max.	8.1	10.9
Glencree	Mean	4.8	9.2
	S.D.	0.4	n/a
	S.E.	0.1	n/a
	n	18	1
	Min.	4.1	9.2
	Max.	5.9	9.2
Glendine	Mean	7.9	
	S.D.	n/a	
	S.E.	n/a	
	n	1	
	Min.	7.9	
	Max.	7.9	
Glenealo	Mean	4.2	
	S.D.	0.4	
	S.E.	0.3	
	n	2	
	Min.	3.9	
	Max.	4.5	
Gowlan	Mean	5.1	14.2
	S.D.	0.8	n/a
	S.E.	0.2	n/a
	n	26	1
	Min.	3.8	14.2
	Max.	7.8	14.2
Greese	Mean	5.2	
	S.D.	0.8	
	S.E.	0.2	
	n	12	
	Min.	3.3	
	Max.	6.9	
Liffey (Lucan)	Mean	5.9	11.9
	S.D.	0.9	1.5
	S.E.	0.2	0.7
	n	26	4
	Min.	4.6	10.7
	Max.	7.8	13.7

APPENDIX 7 continued

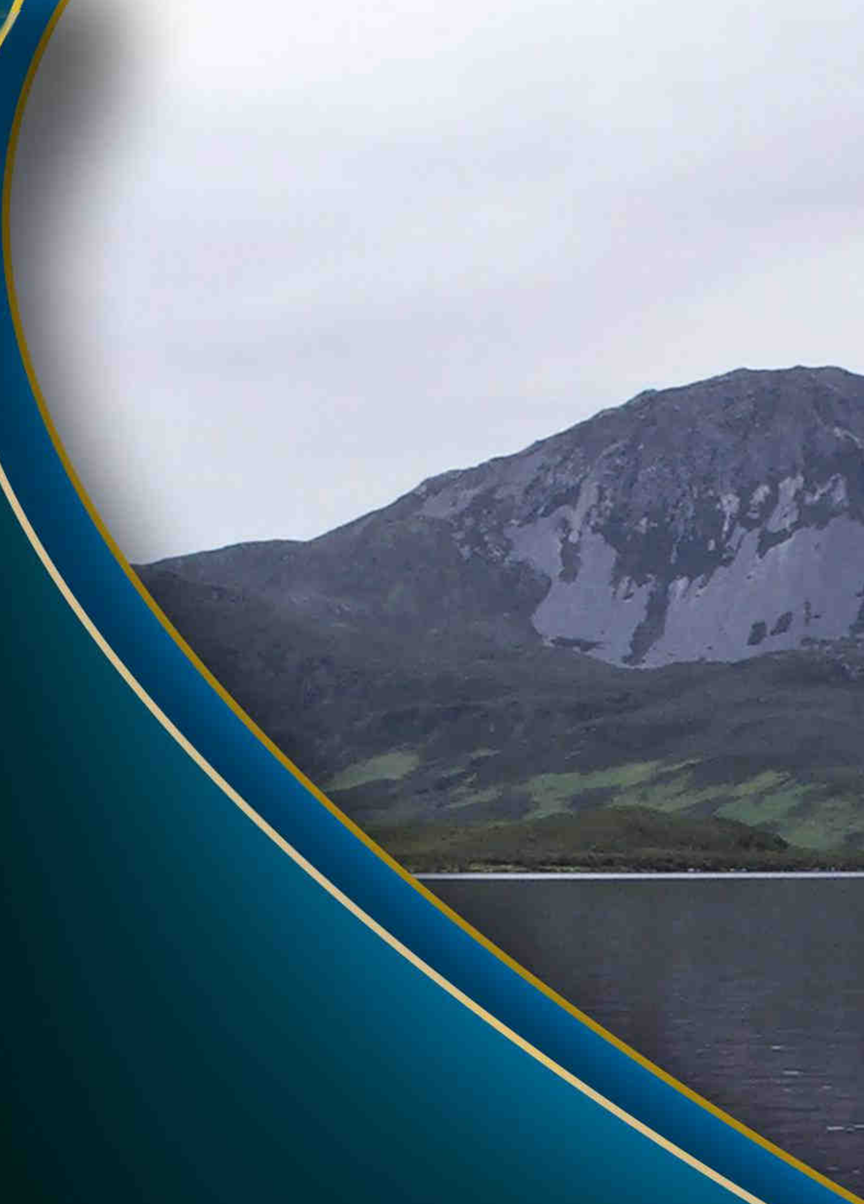
Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River	S.E.	L1	L2
Moyree	Mean	5.9	
	S.D.	0.6	
	S.E.	0.2	
	n	8	
	Min.	4.9	
	Max.	6.7	
Nanny (Tuam)	Mean	4.2	8.5
	S.D.	n/a	n/a
	S.E.	n/a	n/a
	n	1	1
	Min.	4.2	8.5
	Max.	4.2	8.5
Nenagh	Mean	6.5	
	S.D.	1.0	
	S.E.	0.4	
	n	7	
	Min.	4.7	
	Max.	7.8	
Newport	Mean	4.0	8.1
	S.D.	0.8	1.1
	S.E.	0.2	0.3
	n	27	10
	Min.	2.5	6.9
	Max.	5.6	9.5
Owenbrin	Mean	5.2	
	S.D.	n/a	
	S.E.	n/a	
	n	1	
	Min.	5.2	
	Max.	5.2	
Owvane	Mean	5.2	7.9
	S.D.	1.1	1.7
	S.E.	0.2	0.8
	n	23	4
	Min.	3.3	6.3
	Max.	7.1	10.3
Owveg	Mean	4.5	
	S.D.	1.3	
	S.E.	0.2	
	n	33	
	Min.	2.4	
	Max.	7.9	

APPENDIX 7 continued

Summary of the growth of salmon in 36 rivers surveyed in WFD surveillance monitoring 2009 (L1=back calculated length at the end of the first winter etc.)

River	S.E.	L1	L2
Slaney	Mean	5.1	9.6
	S.D.	0.9	1.1
	S.E.	0.2	0.4
	n	22	8
	Min.	3.4	8.1
	Max.	6.6	10.9
Unshin	Mean	4.5	
	S.D.	0.8	
	S.E.	0.2	
	n	16	
	Min.	3.5	
	Max.	6.7	
White	Mean	5.6	10.4
	S.D.	1.3	n/a
	S.E.	0.6	n/a
	n	5	1
	Min.	4.4	10.4
	Max.	7.9	10.4



The Central Fisheries Board
Swords Business Campus,
Swords,
Co. Dublin,
Ireland.

Web: www.wfdfish.ie
www.cfb.ie
Email: info@cfb.ie
Tel: +353 1 8842600
Fax: +353 1 8360060

The Central and Regional Fisheries Boards