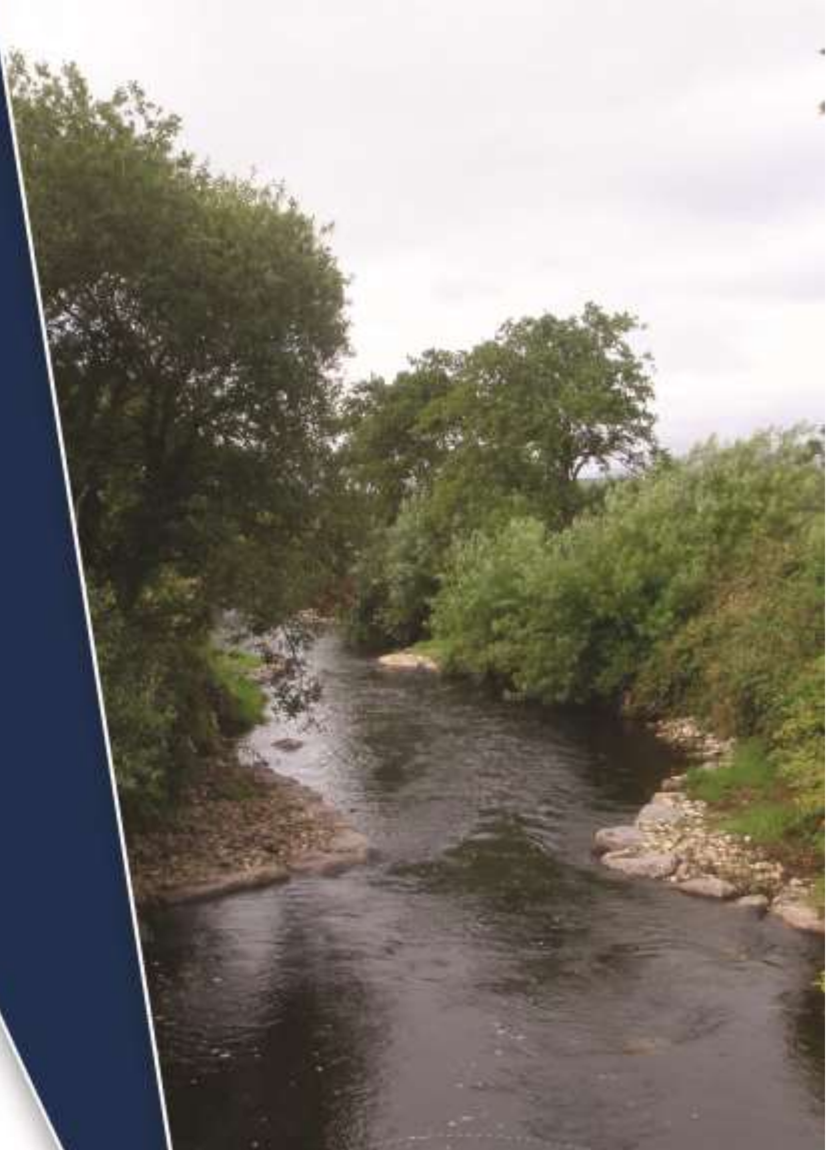
IFI/2016/1-4342



Environmental River Enhancement Programme Review Report 2008 - 2012

2012

IASCACH INTÍRE ÉIREANN
INLAND FISHERIES IRELAND

Iascach Intíre Éireann
Inland Fisheries Ireland

Environmental River Enhancement Programme 2008 – 2012 Final Report

May 2013

Inland Fisheries Ireland

Iascach Intíre Éireann
Inland Fisheries Ireland

The Office of Public Works
Oifig na nOibreacha Poiblí

Acknowledgments

The assistance and support of OPW staff, of all grades, from each of the three Drainage Maintenance Regions is gratefully appreciated. The support provided by regional IFI officers, in respect of site inspections and follow up visits and assistance with electrofishing surveys is also acknowledged. Overland access was kindly provided by landowners in a range of channels and across a range of OPW drainage schemes.

Project Personnel

Members of the EREP team include:

Dr. Martin O’Grady
Dr. James King
Dr. Karen Delanty
Brian Coghlan
Rossa O’Briain
Michelle O’Regan

Table of Contents

1 Introduction

Since the early 1990's the Office of Public Works (OPW) has been in engaged in scientific studies with Inland Fisheries Ireland, IFI (formerly the Central Fisheries Board). The aims of such studies were to identify the environmental impacts of drainage maintenance in OPW channels and to develop alternative strategies that would facilitate environmentally friendly maintenance programmes. In recent years a number of legislative and national polices, such as the EU Water Framework Directive (WFD), the EU Habitats Directive and the National Biodiversity Plan have increased the need for the OPW to consider the ecology of the environment in which they work in. As part fulfilment of these issues the OPW initiated the current five year research project with IFI - Environmental River Enhancement Programme (EREP).

The programme has two major strands – one dealing with river morphology enhancement and the second dealing with the robust implementation of OPW's own environmental protocols on channel maintenance. The effectiveness of these two strands will be assessed through monitoring the impacts of the necessary physical works on the river corridor biodiversity and hydromorphology.

The biodiversity element of the project includes monitoring fish, aquatic macro-invertebrates, riparian and instream vegetation as well as birds using the river corridor in an exclusive manner as part of their ecology. Examination of physical habitat factors and how these may also be impacted both by channel enhancement works and by proactive maintenance is a significant component, complementing the biodiversity studies. Scientific studies investigating lamprey (*Lampetra sp.*) and white-clawed crayfish (*Austropotamobius pallipes*), initiated through previous OPW projects, continue to be monitored also. In 2011 a trout genetics programme commenced. The focus of the genetic studies was to determine what impacts, if any, drainage works may have had on the genetic diversity of trout stocks within drained catchments. These studies were also used to identify which rivers were contributing adult trout to the main channels and/or lakes of the included study catchments. In doing the data generated will help to target future OPW capital works programmes in a more focused manner that would maximise the fish benefit element of the programme.

River enhancement programmes are a capital works initiative whereby IFI design enhancement plans while OPW fund and undertake the works identified using their own resources including field staff and machinery. Work on enhanced maintenance is focused on increasing environmental awareness and improving the implementation (and further development) of the 10 steps of environmental enhancement amongst machine drivers. OPW have committed to achieving 100km of work programmes annually through both strands of the programme.

The Environmental River Enhancement Programme (EREP) is now in its final year of a five year term (2008–2012), having begun in April 2008. Throughout the current year the project made good progress addressing the aims and objectives initially set out, which included the following;

- To identify 100km of OPW channels for EREP annually.
- To select a number of these channels for capital enhancement works and a number for enhanced maintenance works.

- To undertake a biological monitoring programme across a range of these channels, addressing the impacts of works on the river corridor biodiversity and hydromorphology.
- To provide support and advice throughout the implementation period.
- To carry out external audits of machine crews engaged in routine maintenance.
- To provide EREP training to OPW field staff.

As part of the 2012 programme approximately 105km of channel were identified for works through either enhanced maintenance or capital works programmes and 80km were completed. All channels were walked and a written enhancement report provided to OPW. Monitoring of the physical habitat and biological elements pre and post works at a number of these channels, across all OPW regions, is on-going with a number of experimental works also being undertaken. These scientific studies aim to assess the effectiveness of such works on the river corridor biodiversity and hydromorphology. While data is collected annually on fish communities, riparian and instream vegetation, aquatic macro-invertebrates, birds, crayfish and lamprey, it is often more appropriate to have several years data available before a full account of impacts is presented.

Throughout the programme IFI acted as an external auditor in relation to site assessment, implementation of the 10 Steps to environmentally friendly maintenance and the implementation of OPW's own standard operating procedures (SOP's) and environmental protocols (OPW, 2011). Approximately one third of all OPW's drivers were visited annually. Between 2010 and 2011 EREP training courses were held across all three OPW regions and provided to all OPW's field staff. These courses covered such topics as implementing capital works programmes, implementing enhanced maintenance programmes and OPW's own Environmental Management Protocols and SOP's.

EREP has set up a number of databases to collate and store all the biological data that has been and will be collected over the life of the project. These include databases for fish, plants, macro-invertebrates, birds, crayfish and lamprey. Within Inland Fisheries Ireland a number of other research projects are also collecting similar data and, where possible, data sharing is achieved. The EREP project is contributing annually to the WFD, Eel Management and Invasive Species databases. It also provides data and information to a number of non-fishery agencies, including BirdWatch Ireland (BWI), the National Biodiversity Data Centre and the National Botanic Gardens.

2 EREP Programme 2008 – 2012

2.1 Introduction

The EREP programme continues to develop its two major strands – a capital enhancement works programme dealing with enhancement of OPW drained channels and an enhanced maintenance element dealing with the robust implementation of OPW's environmental protocols for channel maintenance. The capital works programmes involve importation of stone and gravels, diggings and placement of materials to create instream physical diversity and bankfull fencing on completion of the instream works. This approach to enhancement works is more specific than that for enhanced maintenance which primarily focuses on the implementation of OPW's own environmental protocols and where suitable and possible instream development work are carried out using available on-site materials. As such capital enhancement work programmes require a greater investment of time and resources for both OPW and the EREP team.

Drainage channels due to their man-made nature have less diversity with more extensive lengths of uniform depths, widths and gradients. Enhancement involves the increase of structural diversity of the river corridor to create a more natural physical form and this is achieved through a range of enhancement techniques such as construction of various instream stone structures, excavating pools and building riffles, fencing of river banks to allow vegetative regeneration etc. Reintroduction of more natural structural diversity within the river corridor increases the species richness in the river and has a positive effect on the whole food web surrounding the river corridor, which supports all the associated habitats and animals. Enhancement works also includes remediation of fish barriers which have positive effects on the access for spawning fish and other aquatic species for large distances upstream.

All enhancement works were carried out using OPW staff and machinery, with IFI's staff working alongside OPW supervisory staff, with a geographic spread throughout the three arterial drainage maintenance regions. All materials required for the construction of enhancement structures were supplied by OPW.

The main focus of the EREP is to achieve enhancement and environmental methods of work to maximise the environmental quality of the Irish drained river corridor while balancing the channel's drainage outfall and flood conveyance capacity. It provides a tool for Ireland to comply with the WFD legislative obligations for hydromorphology.

2.2 EREP Overview 2008 – 2012

Throughout the EREP period 2008 to 2012 a wide range of river enhancement programmes were carried out through either capital works or enhanced maintenance, each involving a site specific plan of instream development work and/ or vegetation management. In total 21 individual catchments and 105 individual rivers were identified for enhancement works (Tables 2.1 & 2.2). The distribution of these works is shown in Figure 2.1. A small number of EREP projects were not achieved this year however and where possible these channels will be included in the programme of works for 2013.

Table 2.1. Number of catchments and rivers included in EREP 2008–2012.

	Capital Enhancement	Enhanced Maintenance
Catchments	13	20
Individual Rivers	36	78

Table 2.2. List of all EREP catchments 2008–2012.

	Catchments	
OPW Region	**CW**	**EM**
West		Bonet
West		Boyle
West	Corrib	Corrib
West		Deele
West	Duff	Duff
West	Mask	Mask
West	Moy	Moy
East	Boyne	Boyne
East	Brosna	Brosna
East	Dee	Dee
East		Glyde
East	Inny	Inny
East	Liffey	
East		Owenavorragh
East		Ward
Southwest		Deel
Southwest	Feale	Feale
Southwest		Groody (Shannon lower)
Southwest	L. Derg (Shannon)	L. Derg (Shannon)
Southwest	Maigue	Maigue
Southwest	Maine	Maine

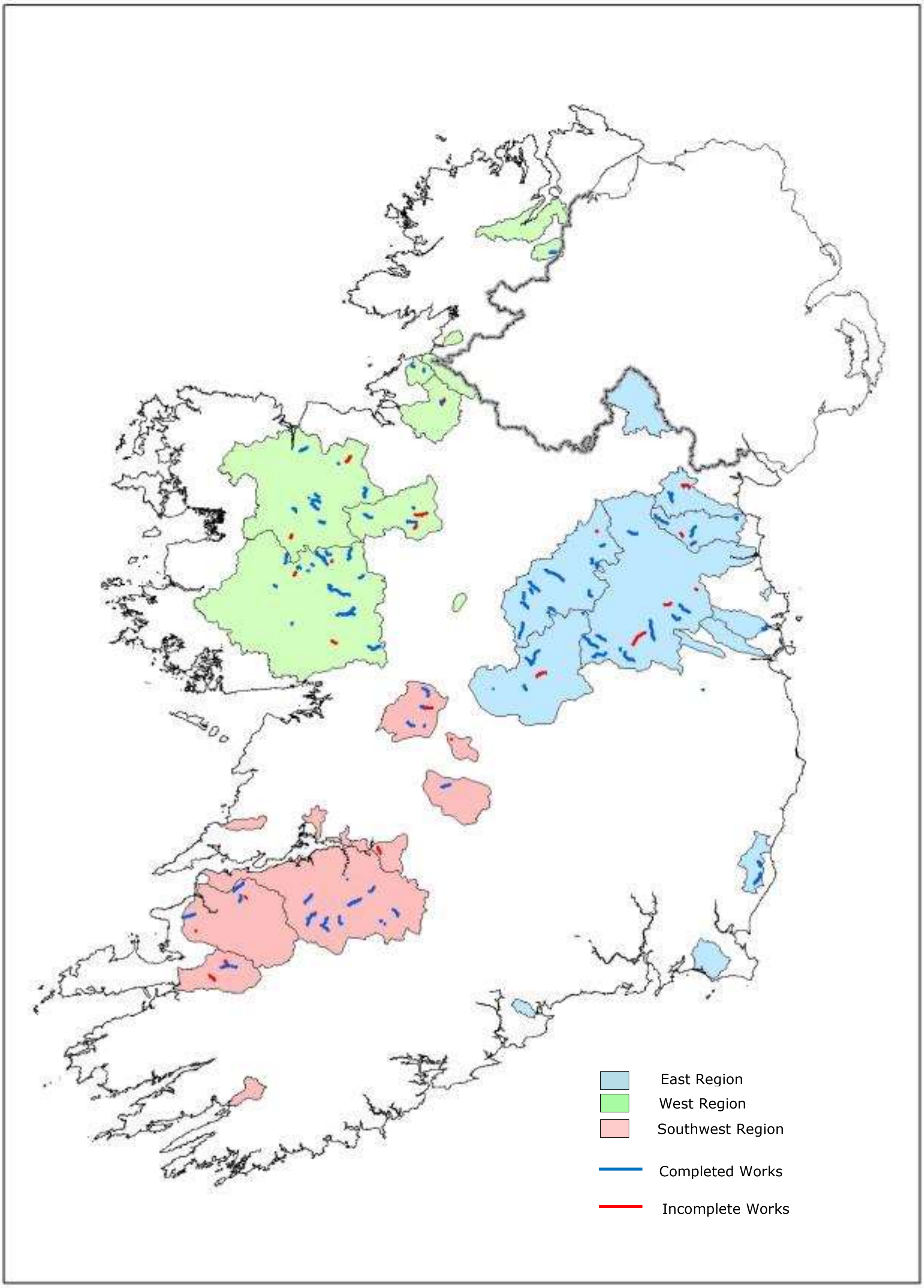


Figure 2.1. Location of all EREP work programmes 2008-2012.

One of the key deliverables of EREP is to identify 100km of OPW drained channels for inclusion in either the capital works programme or the enhanced maintenance programme. This overall target is spread across each of OPW's three drainage maintenance regions, with each region having its own target of works to achieve (Table 2.3).

Table 2.3. OPW Drainage Region targets for EREP.

Region	Capital Enhancement Target (Km)	Enhanced Maintenance Target (Km)
East Region	10	30
South West Region	7	21
West Region	8	24
National Total	**25**	**75**

Targets are set much higher for the enhanced maintenance strand of EREP than for capital works. This is simply because capital work programmes progress at a much slower rate due to the nature of the work being undertaken. On average capital works can be expected to cover somewhere between 150 and 400m a week. Whereas enhanced maintenance would be expected to cover as much as 500 to 1000m a week.

Table 2.4. EREP 'yardage' by OPW Drainage Region, 2009–2011 (values are in metres per week).

	2009	**2010**	**2011**		**2009**	**2010**	**2011**	
	EM	EM	EM	average by region	CW	CW	CW	average by region
East	444	578.83	714.41	579.1	125	385	413.53	307.8
West		410	636.32	523.2	156.25	200	484.46	280.2
Southwest	377	775	579.1	577.0	108.93	145	200.06	151.3
average per year	410.5	587.9	643.3		130.1	243.3	366.0	

Number of weeks each region commit annually on EREP can vary enormously. For example in 2011 the East spent approximately 52 man weeks on enhanced maintenance and had an average 'yardage' of approximately 715m a week. Whereas the West region spent 26.5 man weeks involved in enhanced maintenance and had an average rate of 636m a week. In general though, the average 'yardage' over the three years is very similar for each region. It should also be noted that the average OPW 'yardage' increased each year from 2009 onwards (Table 2.4).

Over the five working seasons of EREP the rate of progress for channel enhancement, be it for capital works or enhanced maintenance, has varied greatly (Table 2.5 & Figure 2.2). For the most part this has been mainly due to weather, in particular very wet summers. High water levels and inaccessible fields made it very difficult to carry out many of the enhancement plans. However it is clear that when the ground is dry and water levels are at 'normal' summer levels, the original targets set for EREP can be achieved. This was the case in 2011 when the full target of 100km of enhancement work was achieved. Unfortunately while enhanced maintenance programmes did proceed successfully in 2012, the capital works side of the project suffered due to constant high water levels. Enhanced maintenance can really be applied to any channel so while the scheduled enhanced maintenance channels may not have been fully completed in 2012 alternative channels were found. This is not the case for capital works.

Table 2.5. Achieved channel lengths for capital works and enhanced maintenance, 2008-2012.

	2008	2009	2010	2011	2012
Capital Works (km)	3.94	8.6	14.97	25.08	2.15
Enhanced Maintenance (km)	12.5	39	47.3	75.22	77.84
Total EREP channel length (km)	**16.44**	**47.6**	**62.27**	**100.3**	**79.99**

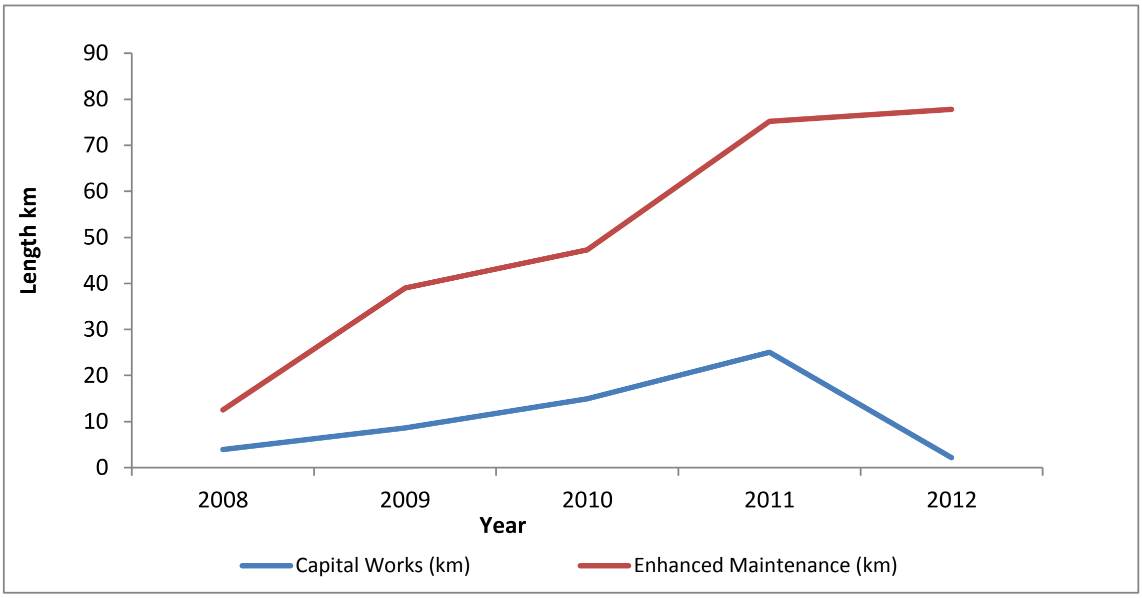


Figure 2.2. Channel lengths achieved through capital works and enhanced maintenance, 2008–2012.

Even though 100km of enhancement works were not always achieved throughout the EREP 5 year period the percentage breakdown of capital works to enhanced maintenance closely followed the target of 25 : 75, with the exception of 2012 (Table 2.6).

Table 2.6. Percentage contribution of capital works and enhanced maintenance to the over-all EREP project, 2008–2012.

	2008	**2009**	**2010**	**2011**	**2012**
Capital Works %	24	18	24	25	3
Enhanced Maintenance %	76	82	76	75	97

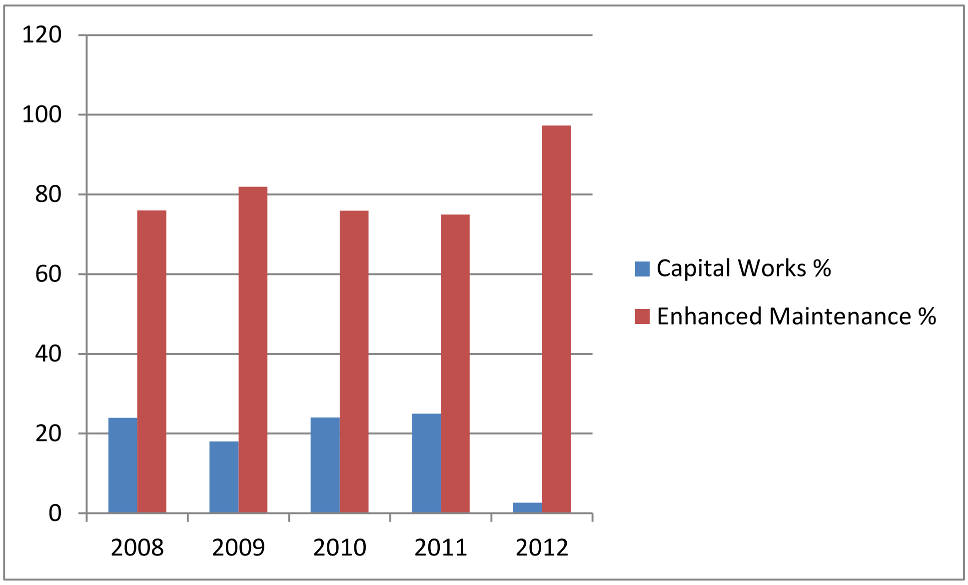


Figure 2.3. Percentage contribution of capital works and enhanced maintenance to the over-all EREP project, 2008–2012.

2.2.1 Capital Works

Inland Fisheries Ireland imposes a 'closed season' for all instream development works undertaken on fishery type channels during the salmonid spawning season. This therefore allows for a very short period of time when instream development works can be carried out and is from July 1st to September 30th. The time frame for completing instream development works is therefore very short and in many cases will limit the amount of capital enhancement works that may be achieved. This window of opportunity for carrying out instream works applies where EREP enhanced maintenance or indeed routine maintenance is being undertaken also in such channels. Another environmental window that impacts on OPW maintenance programmes is that set for tree cutting. The allocated season for tree cutting and pruning is between September 1st and February 28th. Many of the capital and enhanced maintenance programmes require some level of tree management before it is possible to carry out the instream development works and thus time management is critical in such channels.

All channels identified for capital works must meet certain criteria before they will be considered for inclusion in the EREP programme, or indeed any river enhancement programme. The same basic guidelines are used to identify channel sections that would benefit from capital works each year and include the following:

- Water quality should be at least moderate/satisfactory with a Q-value rating of at least Q3-4.

- Ideally work in channels where the gradient is greater than 0.2% (2m/km) but less than 3% (30m/km).

A combination of information and data sources are available to help determine the suitability of potential channels, such as OPW long-section data, flood risk assessments, aerial imagery, Environmental Protection Agency (EPA) Q-value data and consultation with the IFI River Basin Districts. The final decision is then made after a site visit. All capital enhancement plans are available to view, by OPW personnel, through the OPW social text web page.

The enhancement plans generally aim to restore the physical appearance or hydromorphology of the drained river. Increasing habitat diversity and channel form will lead to subsequent changes in the flora and faunal regime which will in turn benefit fish communities. A typical drained river, that has not recovered post drainage, will be uniform in cross-section, overly wide and shallow with little bed material diversity and, in general, have poor habitat diversity. The usual sequence of riffle / glide / pool seen in natural undisturbed rivers will not be evident in these drained channels. The most common morphological problems in drained rivers are an absence of both a well-defined thalweg and quality pool areas and a paucity of gravel deposits suitable for salmonid spawning purposes.

A variety of techniques can be used to restore these imbalances. The method chosen will depend on the size of the channel, channel gradient and existing bed material. Typical capital enhancement works take the form of supplying gravels to increase spawning habitat, supplying rock/stone or other suitable materials to form a variety of instream structures such as deflectors, weirs, random boulders, rubble mats etc, altering structures to improve fish passage, excavation of pools and thalweg, localised bank reinforcement, erection of riparian fencing (subject to landowners agreement) to improve riparian habitat and integrating any further enhancement options which are deemed viable that will benefit the river corridor biodiversity by providing niche habitats or particular species requirements.

Over the years the rate of capital works has varied (Table 2.7). This variation has been due to a number of factors, the same of which are true for the enhanced maintenance side of the project.

- Training up staff.
- Level of supervision required.
- OPW support (through foreman & technical staff).
- Weather.
- Flood relief scheme pressures.
- Availability of alternative IFI plans.

Table 2.7. Capital works achieved in each OPW Drainage Region (km), 2008–2012.

		Capital Works			
OPW Region	**Target**	2009	2010	2011	2012
East	**10**	2.5	5.4	11	0
Southwest	**7**	1.5	5.9	7.2	1.3
West	**8**	3.4	2.8	6.8	0.85
	25	7.4	14.1	25	2.15

The data was also plotted with the OPW region target also show (Figure 2.4, OPW targets shown as dashed line). It is very clear that capital works targets are rarely being met. The only year regional targets were achieved was in 2011, the only year that summer conditions were suitable for long periods of time and thus allowed all programmes to be successfully implemented. While a few other factors may affect work progress weather conditions are the most critical.

Unfortunately weather conditions cannot be controlled. Measures that could be taken to help improve the success of capital works programmes would be to have a number of plans available that would cover both large and small rivers and perhaps to have them spread out around the region. Therefore if the larger rivers were in flood there may be an option to do work in the smaller channel especially if it was in a different catchment. Also good resource management by OPW's engineering staff and foremen- who could be in a position to reschedule work programmes to suit weather conditions. This should be aided by the availability of capital work plans a year ahead of schedule, or at least prior to the completion of OPW's Drainage Maintenance Programme for the following year. It is also critical for the relevant engineer to take part in the walk-over survey to identify any issues there may be which could be addressed over the winter/spring prior to the start date for such plans. This would avoid delays in start times and the possibility of works having to be rescheduled until the following year.

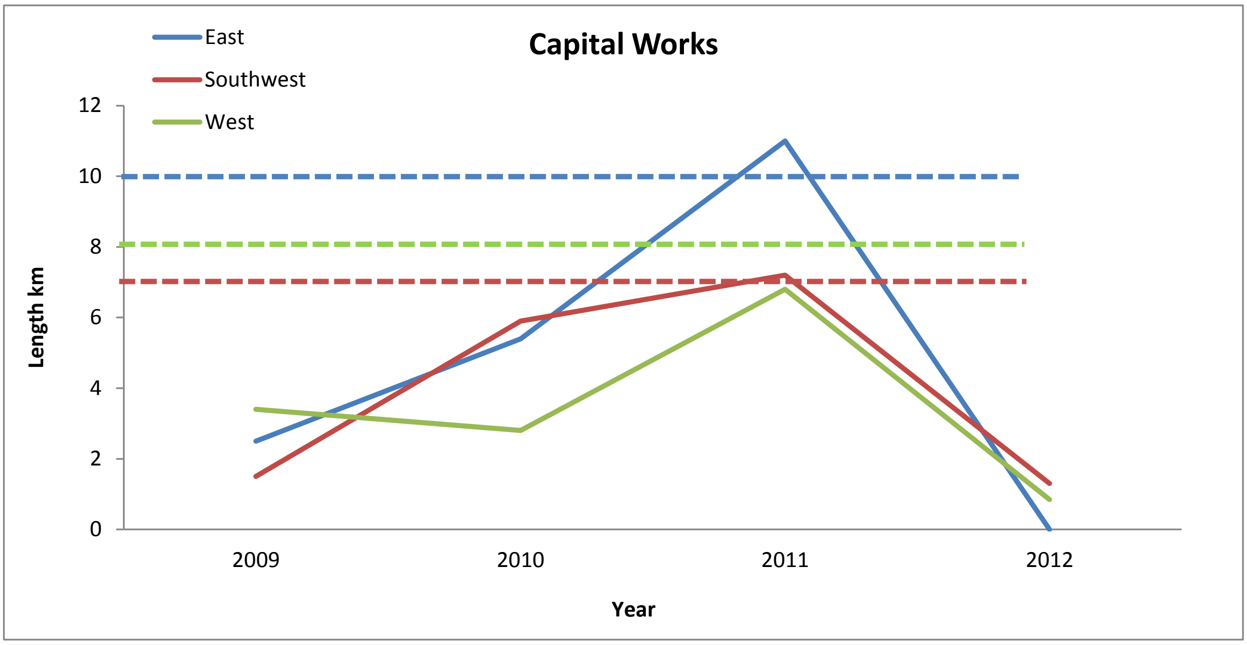


Figure 2.4. Capital works achieved by OPW Drainage Regions and the targets set for each region (dashed lines).

2.2.2 Enhanced Maintenance

Choosing channels for inclusion under enhanced maintenance is somewhat different to that for capital enhancement works. Generally speaking, channels here are identified for works based on the variety of maintenance requirements that may need to be undertaken and on opportunities for the OPW staff to implement a wide selection of the 10 training points relating to enhanced maintenance. Not all channels selected will be important fishery channels, but will still have a whole host of other wildlife communities associated with them, such as birds, bats, small mammals, plants and all sorts of insects, and maintenance works within these channels can have a significant impact on the whole river corridor bio-diversity. The enhanced maintenance works are also intended, in many cases, to impact positively on the channel form or hydromorphology. All channels identified for EREP works are selected from OPW's own Channel Maintenance Programme for that year.

Channels designated for enhanced maintenance should be seen as training sites or demonstration channels where support and supervision of works is available to machine drivers and foremen. The lessons and advice given on-site at these channels should allow machine drivers and foremen to carry out similar works on similar type channels which have not been walked and visited by the EREP team. This is particularly important if OPW are to ensure that routine maintenance is being managed according to their 10 Steps to Environmental Maintenance. It is no longer an option to implement environmental maintenance on selected channels only. It is OPW's target to achieve a relevant or appropriate level of implementation of the 10 steps to environmental maintenance on every channel where normal routine maintenance is required. There may be occasions though where it may not be possible for all environmental measures to co-exist with flood relief measures and allowances will have to be made to accommodate these exceptions.

The enhanced maintenance side of the project has always had greater targets to achieve, in terms of 'yardage' solely because the implementation of such works do not significantly impact on resources such as staff, equipment and time (Table 2.8 & Figure 2.5), as is the case with capital works.

Table 2.8. Enhanced Maintenance achieved in each OPW Drainage Region (km), 2009-2012.

		Enhanced Maintenance			
OPW Region	**Target**	2009	2010	2011	2012
East	**30**	13.7	12.9	36.9	44.2
Southwest	**21**	10.2	17	21.4	20.9
West	**24**	22.9	17.4	16.9	12
	75	46.8	47.3	75.2	77.1

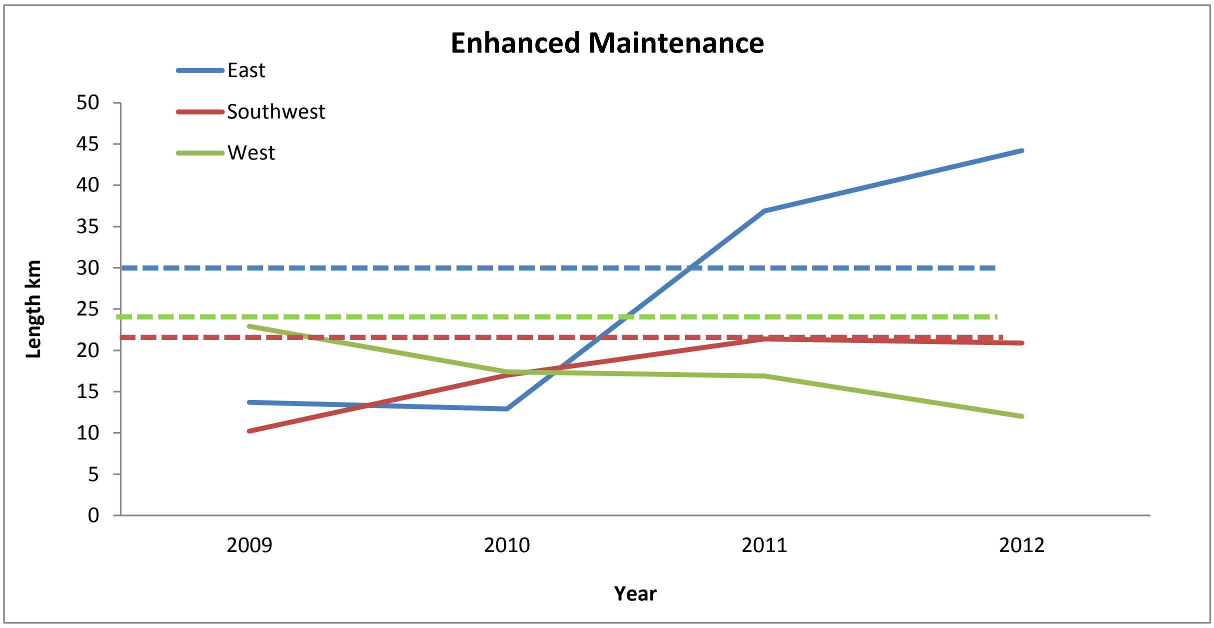


Figure 2.5. Enhanced Maintenance achieved by OPW Drainage Regions and the targets set for each region (dashed lines).

3 Bio-diversity and EREP Monitoring

The EREP biological monitoring programme aims to assess the impacts of capital works and of routine environmental maintenance on the river corridor bio-diversity. Fish, flora, birds, macro-invertebrates, lamprey and crayfish, along with physical changes are being monitored across a number of sites.

3.1 River Corridor Bio-diversity

Our monitoring studies have shown that the temporal response exhibited by the various river corridor elements, that we sample, can differ (EREP Annual Reports 2008 to 2011). Our results also indicate that often the changes seen across the whole site can be interlinked. Enhancement of the physical regime can greatly improve the channel diversity, through restoration of the riffle / glide / pool sequence, addition of spawning gravels, bank protection and the like. Such changes can improve the fish carrying capacity of these rivers. Fish dynamics will alter in response to the newly created habitat, with changes to population structure and abundance often noted. Indeed species composition may also be effected.

Sites chosen for capital works programmes will often exhibit limited salmonid potential for spawning opportunities, nursery waters, angling or a combination of these. As capital works programmes address these issues, there is the expectation that if the spawning potential has improved then we should see increases in 0+ fish numbers. Enhancement works in potential nursery waters should see the 1+ population improve while angling development, in salmon (*Salmo salar*) and trout rivers, should provide for greater numbers of adult fish.

As the physical aspect of the channel changes in response to an altered hydrology, there will be corresponding changes in the floral communities. For example the reintroduction of a proper thalweg may increase the gravelly nature of bed material in scoured areas encouraging the growth of species like *Ranunculus*. In contrast in sections with increased sediment deposition one may see an increase in emergent plant species like *Phalaris* or *Sparganium*.

Often changes in the aquatic, marginal and riparian vegetation will see changes in the macro-invertebrate communities. Increased vegetation cover and diversity will often correspond to increased invertebrate diversity and abundance. Both vegetation and the invertebrate fauna are important to the fish communities present in any channel.

However flora and fauna communities respond to change at differing rates. Some of the improvements mentioned may occur immediately, others over a number of years. For example it is not surprising to record increases in fish spawning and for older fish to move into deeper waters/pool areas almost immediately post works. The benefits to the floral and macro-invertebrate communities often take longer to materialise.

Most capital works programmes do not actually change the flora or fauna of the channel directly, i.e. no plants, invertebrates or fish are actually reintroduced. What the EREP programme does is to provide the channel with the necessary conditions/habitats it needs to achieve such changes itself.

Changes to the channel come through enhancement of the morphological features of the river. If a channel has the appropriate hydromorphological conditions, then the rest should come naturally. If this does not happen, then most likely the river has water quality issues which are beyond the remit of this programme.

3.2 Fish Studies

3.2.1 Fish Monitoring Programme

Introduction

From 2008 to 2012 the EREP programme selected a number of capital works and enhanced maintenance sites for fisheries monitoring. This was to quantify the effect of capital works and enhanced maintenance on brown trout (*Salmo trutta*), salmon and the greater fish community. This report analysed 19 sites from the Boyne, Glyde and Dee, Maigue, Maine, and Moy catchments, to see whether or not the changes recorded in fish stocks were statistically significant and in a positive way.

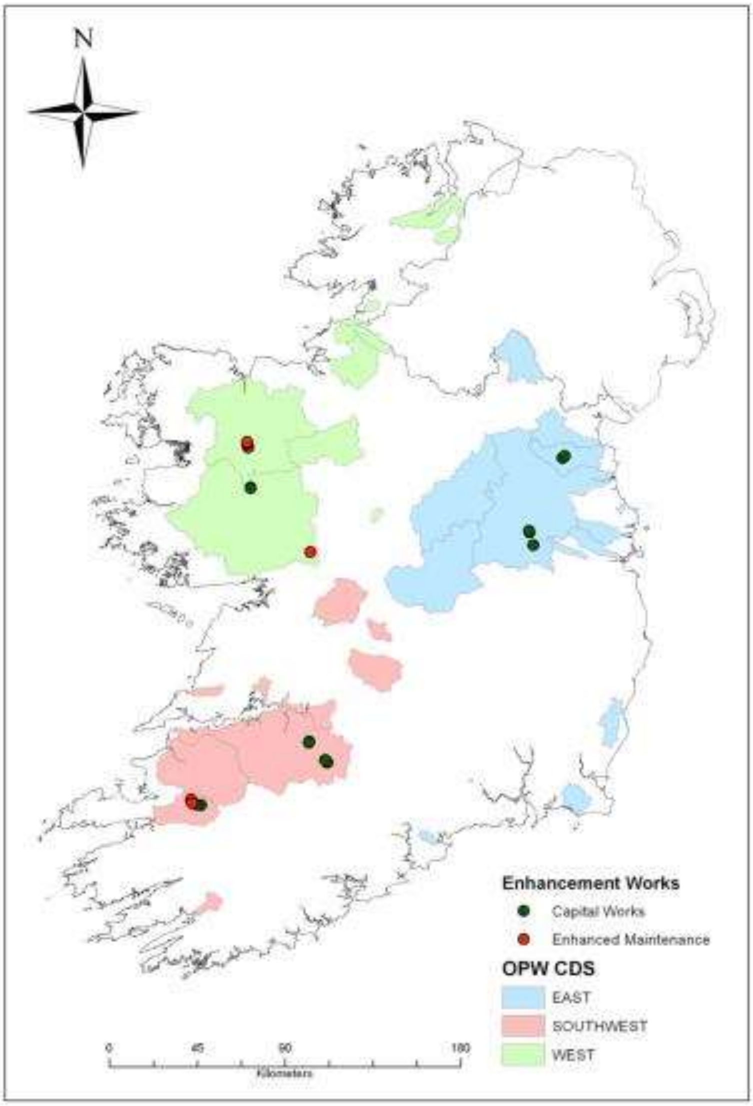


Figure 3.1. Capital works and enhanced maintenance locations where electrofishing data was collected.

Methodologies

Minimum density (no./m^2) estimates have been used in the analyses, this approach had two advantages: it standardised and maximised the size of the data set thereby increasing the power of the statistical analysis and allows comparison with previous work undertaken in IFI (O'Grady & O'Leary, 2007).

Monitoring the effectiveness of the enhancement programmes was carried out as follows:-

- Channel reaches were selected as experimental sites, where enhancement programmes works were to be undertaken. These sites were electrofished prior to the enhancement programme, one year post works and possibly two years post works. For the purpose of this report these surveys are described as pre and post works experimental sites.

- Channel reaches were selected as control sites; these were locations where no works would be undertaken. These sites are used as comparisons to enhanced sites and are fished in conjunction with the experimental sites.

- Control and experimental reaches were re-fished at the same time of year as they had been fished prior to the implementation of the enhancement programme.

- No two stream reaches are identical; in addition the overall fish density in any stream can vary significantly from year to year. Consequently, three questions need to be addressed, (a) if salmonid numbers at the experimental site were significantly different pre and post works and (b) if salmonid numbers pre and post works at the control sites were significantly different, or not. If no significant differences were evident for (a) and (b) above, then a third hypothesis was examined – whether, or not, there were significant differences between the salmonid numbers in experimental and control sites post works. In these circumstances any such differences would only be significant statistically if the salmonid numbers in the experimental and control sites, pre works, were not significantly different to begin with.

- Examining the effect of the enhancement programme on trout and salmon, initially the two species were grouped allowing the effect of the enhancement programme on salmonids to be examined. If significant differences were found the data would be interrogated further examining the effect capital works and enhanced maintenance programmes had on both trout and salmon and their life stages.

- Data was transferred into the statistical software package QED V. 1.1.3.456 and examined.

- Data was found to be non-normally distributed and any attempt to transform the data to a normal distribution was unsuccessful. Due to this non-normal distribution non-parametric statistics (Kruskal Wallis, Mann-Whitney U) were used to analyse the data.

- A Kruskal-Wallis test was performed, examining the difference in densities of salmonids and other species between control pre, control post, experimental pre and experimental post.

- The Mann-Whitney U test was used as a non-parametric post-hoc test. When a significant value is obtained a post-hoc test is performed in order to determine exactly where the differences in densities occur, e.g. between which of the 4 variables.

- The Mann-Whitney U test was used to test if significant differences were detectable between the minimum densities of salmon and trout and their life stages when comparing experimental pre/experimental post and control pre/control post.

3.2.2 Data Analysis

Salmonids

The Kruskal–Wallis one-way analysis of variance test was used to examine the effect of both enhanced maintenance and capital works on salmonid densities pre and post works.

- No significant difference was detected between pre and post work salmonid populations when comparing all EREP enhancement programmes as a whole.

Capital works and enhanced maintenance sites were then tested separately for their effect on salmonid densities pre and post works. Reviewing the data it becomes apparent there was insufficient data to analyse the enhanced maintenance fisheries data in any detail. No further analysis of enhanced maintenance was undertaken.
The capital works data was then individually tested using the Kruskal–Wallis test for its effect on salmonid densities

- In the capital works programme no significant difference was detected between pre and post work salmonid populations.

To further analyse the capital works data anomalous data was identified and removed. The Morningstar experimental and control series was identified and removed from the analyses, the rationale is that in 2010 the river suffered a significant pollution event and fish kill.

Reanalysing the capital works data using the Kruskal–Wallis test with the Morningstar series removed:

- There is a significant difference ($H = 8.02077$, $P = <0.05$) in salmonid minimum density medians between the control pre, control post, experimental pre and experimental post in the capital works programme.
- A Mann-Whitney U post hoc test was used to identify where the significance lay between the four categories (control pre, control post, experimental pre and experimental post). The data indicates a significantly higher salmonid density in the experimental post compared to the experimental pre ($U = 24$, $P = <0.05$) at the capital works sites. This is still significant with a Bonferroni correction of 0.0125 applied (Bonferroni correction is a method used to counteract the problem of multiple comparisons. It is considered the simplest and most conservative method to control the probability of making false discoveries among hypotheses when performing multiple hypotheses tests).
- There was no significant difference in salmonid densities between control pre and control post at the capital works sites.

Salmon and trout densities were then individually analysed using the Kruskal–Wallis test to see if there were significant statistical differences in their densities between control pre, control post, experimental pre and experimental post in the capital works programme.

- There is a significant difference (H = 7.44148, P = <0.05) in salmon minimum density medians between the control pre, control post, experimental pre and experimental post in the capital works programme.
- There is no significant difference (H = 5.16649, P = >0.05) in trout minimum density medians between the control pre, control post, experimental pre and experimental post in the capital works programme.

A Mann-Whitney U post hoc test was used to identify where the significance lay in the salmon minimum densities between the four categories (control pre, control post, experimental pre and experimental post).

- The data indicates a significantly higher salmon density in the experimental post compared to the experimental pre (U = 31.5, P = <0.05) at the capital works sites. This is still significant with a Bonferroni correction of 0.025 applied.

Salmon fry and salmon parr densities were then individually analysed using the Kruskal–Wallis test to test if there is a significant statistical difference in their densities between control pre, control post, experimental pre and experimental post in the capital works programme.

- There was no statistical difference in salmon fry and salmon parr minimum densities between the control pre, control post, experimental pre and experimental post capital works.

Low site and sample numbers do not allow for rigorous analyses of trout and salmon life stages and their response to capital works. However it is possible to compare pre and post works both at the capital works and control sites to show the general impacts of capital works on the life stages of both trout and salmon. The effect of capital works on the minimum densities of salmon and trout and their life stages are shown in figure 3.2 which also gives the standard deviations of the average minimum densities. This shows how much variation or "dispersion" exists around the average. It’s this variation which will be reduced with larger site and sample numbers.

Mann-Whitney U tests were used to identify whether there was a significant difference in trout or salmon densities between the experimental pre and experimental post sites and the control pre and control post sites.

- Comparing all trout life stage densities between the experimental pre and experimental post sites a significant difference is detected between the medians (U = 31, P = <0.05), all trout densities post works are larger than all trout densities pre works. This is significant with a Bonferroni correction of 0.025 applied. Comparing all trout life stage densities at the control pre and control post sites, no significant difference was detected between the medians.
- Comparing all salmon life stage densities between the experimental pre and experimental post sites, a significant difference is detected between the medians (U = 31.5, P = <0.05). All salmon densities post works are larger than all salmon densities pre works. This is significant with a Bonferroni correction of 0.025 applied. Comparing all salmon life stage densities at the control pre and control post sites, no significant difference was detected between the medians.

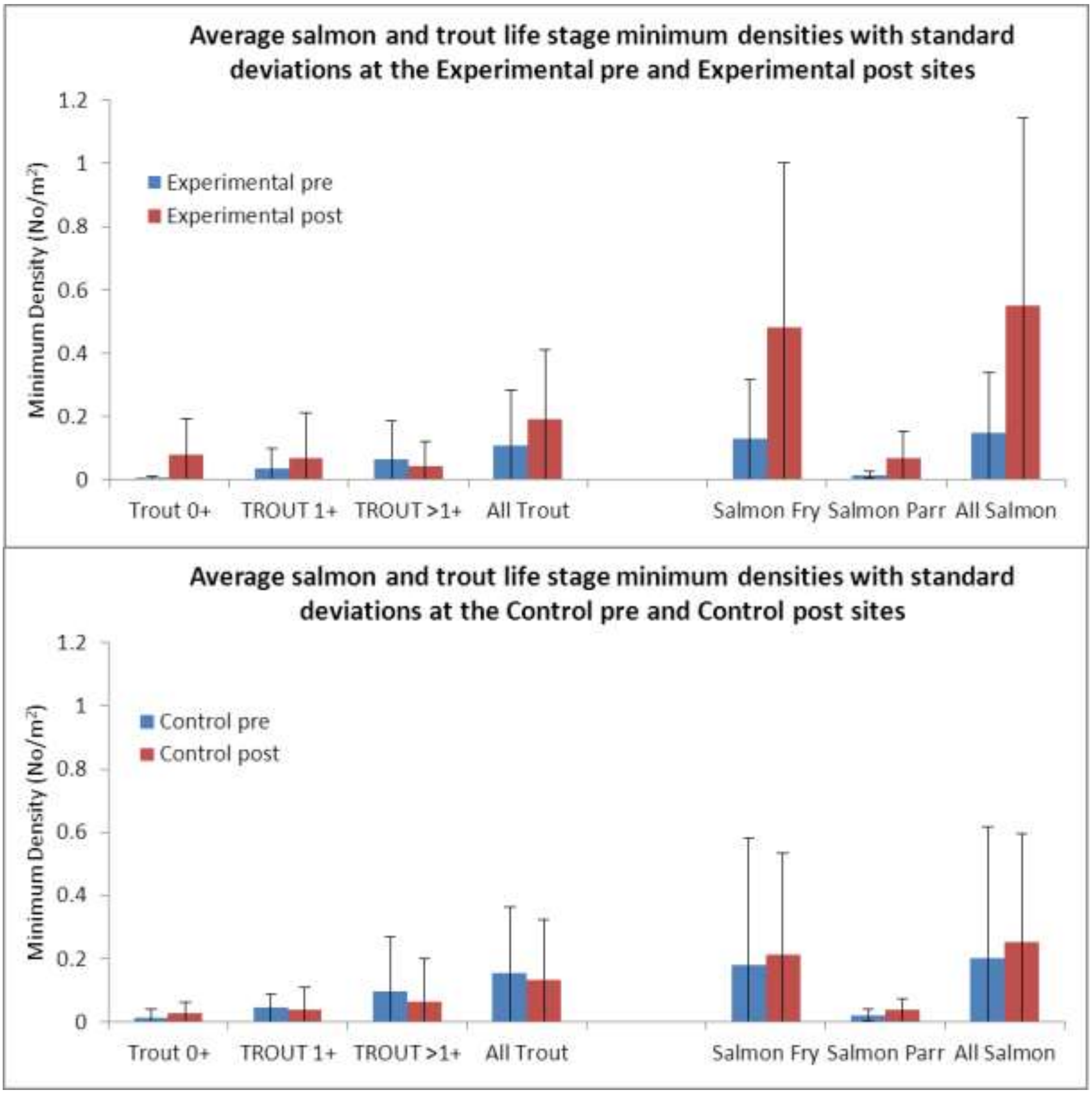


Figure 3.2. Average salmon and trout life stage densities (no./m^2) at the experimental pre and experimental post sites and at the control sites pre and post capital works.

A Mann-Whitney U test was used to test significance differences in salmon and trout life stages between the experimental pre and post works and the control pre and control post sites.

- Densities of 0+ trout are significantly higher ($U = 25.5$, $P = <0.05$) in experimental post sites compared to experimental pre sites. This is significant with a Bonferroni correction of 0.025 applied. There is no significant difference in the 0+ trout densities in the control pre and control post work sites. No significant difference was detected between 1+ trout and >+1 trout pre and post in either the experimental or control sites.
- Densities of salmon fry are significantly higher ($U = 32$, $P = <0.05$) in experimental post sites compared to experimental pre sites. This is still significant with a Bonferroni correction of 0.025 applied. Comparing salmon fry densities at the control pre and control post sites, no significant difference was detected between the medians. Salmon parr densities are not significantly different ($U = 36.5$, $P = >0.05$) when experimental post sites are compared to experimental pre sites, once a Bonferroni correction of 0.025 applied. No significant difference was detected in salmon parr between the control pre and control post sites.

Capital works: Other fish species

The minimum densities of the 5 most abundant other fish species and crayfish (minnow (*Phoxinus phoxinus*), stoneloach (*Barbatula barbatula*), three-spined stickleback (*Gasterosteus aculeatus*), lamprey, white clawed crayfish and eel (*Anguilla anguilla*) were summed and analysed to assess the effect of enhancement on non-target species. A Kruskal-Wallis test was performed, examining the difference in other species between control pre, control post, experimental pre and experimental post.

- No significant difference was detected in the minimum densities of other fish species at the capital works sites when the control pre, control post, experimental pre and experimental post sites were compared.

Conclusion

The capital work programmes undertaken through EREP have had a statistically significant beneficial effect on salmonid densities, in particular in relation to salmonid fry numbers. The positive impact of capital works through changes in the morphology and ecology of the channel is seen in the significant increases of salmonids in enhanced river reaches. The fact there is a significant increase in salmonid numbers in enhanced areas, relative to pre enhancement and control sites, in the first year post works is a reflection of the morphological changes with the reintroduction of the physical habitat requirements of salmonids.

This report is unable to rigorously comment on the effect of capital works on salmon and trout life stages (fry and parr), as additional site and sample numbers would be required. Salmon fry and 0+ trout densities are significantly higher in the experimental sites post works. However, it is impossible to rule out natural fluctuations in causing this effect due to low site and sample numbers but, it is probable that the introduction of spawning gravels in capital works sites explain most of the increases observed in salmon fry and 0+ trout densities.

Changes within the adult trout population have not been recorded in enhanced areas. Hunter (1991) expressed the view that brown trout populations in enhanced channels will not reach optimum levels for a five to six year post enhancement period. Channels which have a capacity to support adult fish will, post enhancement, probably reach peak carrying capacity 5 years post works.

Fisheries data from the enhanced maintenance strand of EREP was not analysed separately in this report. This was due to low site and replicate numbers, only two sites with six replicates were available for analyses. This was primarily due to enhanced maintenance works not being completed on channels where pre works surveying was undertaken due to changes in work programmes.

Testing the effect of capital works and enhanced maintenance on other species e.g. minnow, stoneloach, three-spined stickleback, lamprey, crayfish and eel will take a much larger data set. Unlike trout and salmon these species are not uniformly distributed across analysed sites. The patchy distribution of individual species makes analyses impossible until a larger data set is collected. Lamprey and crayfish are not effectively captured (unless specifically targeted) using the electrofishing methodology that this study is based on. Therefore the results showing no impact of capital works and enhanced maintenance on these species must be viewed with caution until further work is completed.

This analysis, underlines the need for good water quality in capital enhancement sites. The Morningstar capital works site was subjected to a significant pollution event post capital works. The removal of the Morningstar data set from the overall analysis allowed a significant result to be detected in the capital works data as a whole. Analyses of the Morningstar data shows no significant difference in the capital works site pre and post works and a decrease in salmon numbers post works. The pollution event negated any positive impact of the capital works programme on the salmon and trout community of the river.

These results reflect pervious work undertaken by IFI (O'Grady & O'Leary, 2007) and other authors which have shown significant increases in numbers of salmon and/or trout one year after the completion of an enhancement programme. Whiteway *et al.* (2010) reported that in a review of 211 enhancement projects a significant increase in salmonid density (mean effect size 167%) and biomass following the installation of structures. Recovery rates of salmonid stocks, post enhancement, are fast. The capacity of channels to support 1+ year-old salmon and/or trout usually increases very significantly only one year after work (O'Grady & O'Leary, 2007). Similar results have not yet been shown in this study, which may be due in part to the relatively small dataset available or related to the type of capital works undertaken which involved the importation of a lot of additional spawning gravels. In many cases scientific data also suggest that adult trout populations will probably not reach optimum levels until circa 5 years post enhancement.

Table 3.1. Statistical analyses summary in relation to fish monitoring pre and post works.

Capital Works Comparing All Sites (Morningstar series Removed)			
(Control pre, Control post, Experimental pre and Experimental post)			
Has capital works created a significant difference between all sites?			
Salmonids	**YES**		
	Salmon	**Yes**	
		Salmon Fry	No
		Salmon Par	No
	Trout	No	
Capital Works Comparing Expermental Sites Pre and Post Works			
Has capital works created a significant difference between Experimental sites?			
Salmonids	**YES**		
	Salmon	**Yes**	
		Salmon Fry	**YES**
		Salmon Par	No
	Trout	**Yes**	
		0 + Trout	**YES**
		1+ Trout	No
		> 1+ Trout	No
Comparing Control Sites Pre and Post			
Is there a significant difference between control sites?			
Salmonids	No		
	Salmon	No	
		Salmon Fry	No
		Salmon Par	No
	Trout	No	
		0 + Trout	No
		1+ Trout	No
		> 1+ Trout	No
Yes = Significant Difference (P =<0.05)			
No = No significant difference (P = >0.05)			

3.2.3 Fish Population Index surveys for 2012

Two Fish Population Index (FPI) surveys were carried out in 2012, the Monaghan Blackwater system (part of the Lough Neagh System) and Matt River, a smaller east coast catchment.

Monaghan Blackwater

The Blackwater catchment can be divided into two sub-catchments; the Border Blackwater and Mountain Water and the Monaghan Blackwater and Clontibret River. The Border Blackwater, Mountain Water, Monahan Blackwater and Clontibret River join to form the Ulster Blackwater which is one of the main tributaries of Lough Neagh.

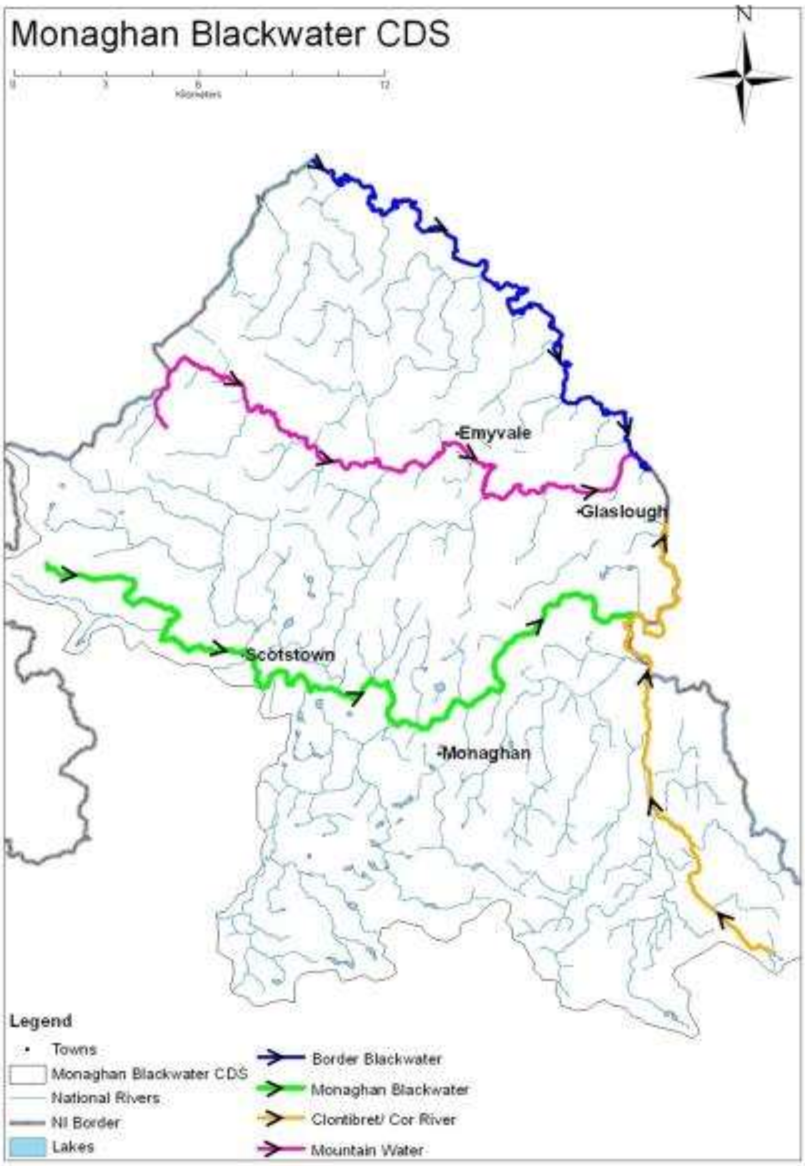


Figure 3.3. Monaghan Blackwater CDS with its main rivers the Border (Ulster) Blackwater, Mountain Water, Monaghan Blackwater and Clontibret (Cor) River. (Arrows indicate direction of flow)

The Border Blackwater rises in Northern Ireland in the mountains to the north east of Fivemiletown. Its first major tributary the Fury River originates on the northern slopes of Slieve Beagh. It is then joined by the Holywell Burn, Oona, Torrent and Ballygawley Rivers before merging with the Mountain Water. The Mountain Water rises in the Slieve Beagh SPA (Special Protected Area). The Border Blackwater then joins the Monaghan Blackwater south of Caledon before flowing as the Ulster Blackwater and discharging into Lough Neagh. The Mountain Water drains two significant lakes, Emy Lough and Glaslough Lake. The Border Blackwater divides County Armagh and County Tyrone and also divides County Tyrone with County Monaghan.

The section of interest of the Border Blackwater and its tributaries for IFI and OPW is from the confluence of the Ballygawley River to where it flows back into Northern Ireland at Mullyjordan. This includes all tributaries on the right bank from the Ballygawley River outfall to where the Border Blackwater crosses back into Northern Ireland.

66% of this catchment is falling below the acceptable standard for the Water Framework Directive (WFD) and this is reflected in the Fish Population Index (FPI) survey. The Environmental Protection Agency (EPA) has 15 macro-invertebrate sampling stations in the Blackwater catchment, 7 are poor, 3 are moderate, 4 are good and 1 is high (Figure 3.4). Based on the findings of Kelly *et al*. (2006) habitat enhancement for salmon should only be undertaken if a Q3-4 or greater is achieved, with trout slightly more tolerant at Q3. Consequently, any work undertaken in zones where water quality indicator values are below a Q3 will not be effective, in terms of increasing salmonid production. Therefore even though there is significant scope for capital works in the Blackwater catchment, due to poor water quality the potential for capital works is severely curtailed.

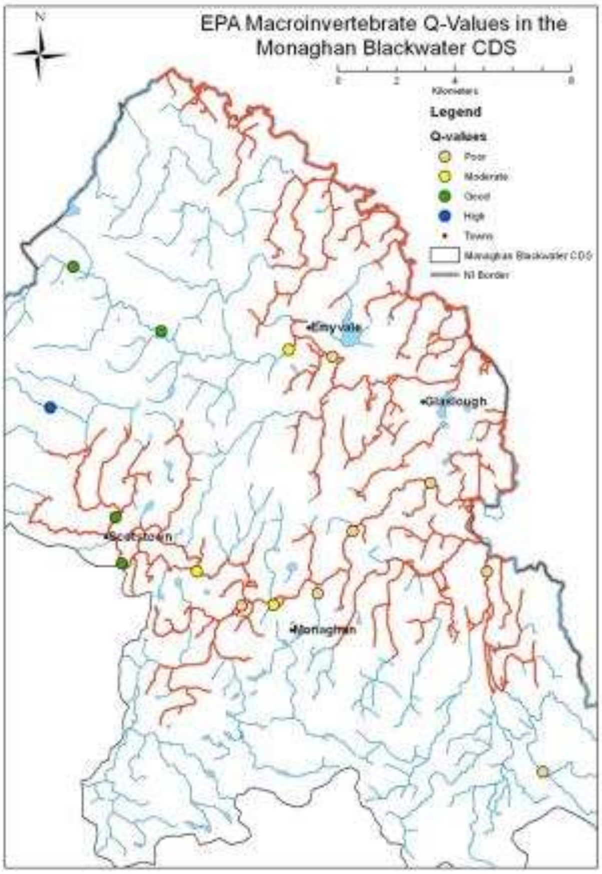


Figure 3.4. EPA macro-invertebrate Q-values for the Monaghan Blackwater CDS (Blue channels are national rivers; red channels are part of the OPW drainage scheme).

The Monaghan Blackwater drainage scheme was started in 1985 and completed in 1992, the OPW maintains 284km's of channel in the Blackwater catchment approximately 51% of the rivers in the catchment. The Border Blackwater and Mountain Water rivers have 123km's of maintained OPW channels and the Monaghan Blackwater and Clontibret Rivers have 161km's of OPW channel.

Nineteen bank based sites and 9 boat based sites were sampled throughout the Border Blackwater and Mountain Water rivers combined. In decreasing order of abundance, fish species captured during the bank based surveys were minnow, trout, three-spined stickleback, stoneloach, crayfish, roach (*Rutilus rutilus*), lamprey, and gudgeon (*Gobio gobio*) (Figure 3.5, Appendix I). No salmon or pike (*Esox Lucius*) were captured in the bank based electrofishing sampling. In decreasing order of abundance fish species captured during the boat based surveying were trout, salmon, gudgeon, roach, minnow, pike, stoneloach, perch (*Perca fluviatilis*) and eel (Figure 3.5). No three-spined stickleback, crayfish or lamprey species were captured during the boat based electrofishing sampling.

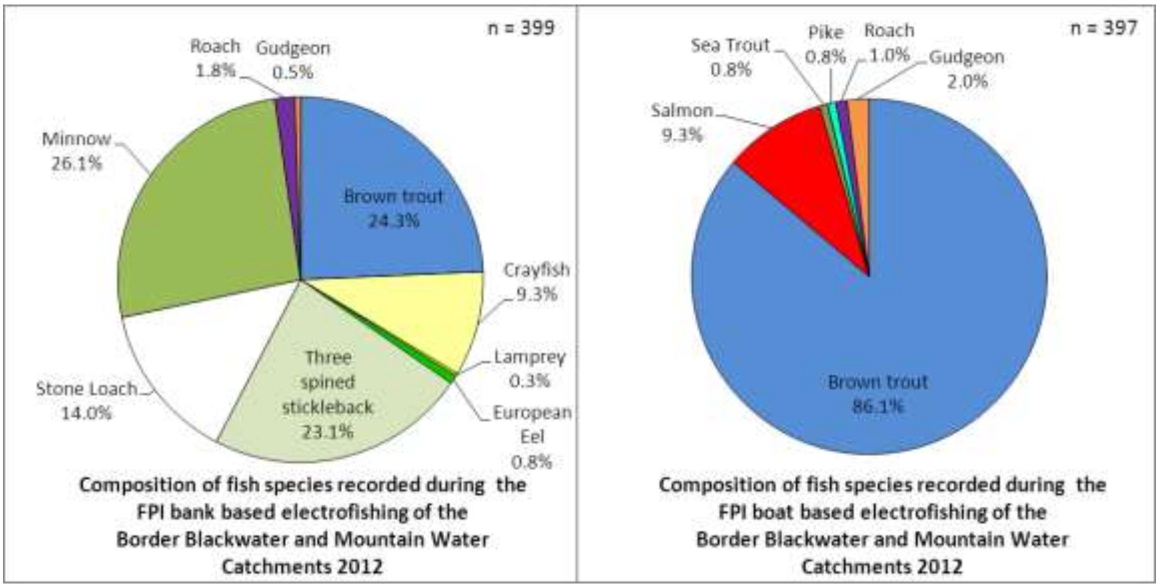


Figure 3.5. Composition of fish species recorded during the Border Blackwater and Mountain Water FPI surveys, using boat and bank electrofishing equipment.

Twenty six bank based sites and 3 boat based sites were sampled on the Monaghan Blackwater and Clontibret rivers. In decreasing order of abundance, fish species captured during the bank based surveys were trout, three-spined stickleback, crayfish, stoneloach, roach and lamprey, eel and pike (Figure 3.6, Appendix I). No salmon, minnow or gudgeon were captured in the bank based electrofishing sampling. In decreasing order of abundance fish species captured during the boat based surveying were trout, roach, minnow, gudgeon, eel, pike and lamprey (Figure 3.6). No salmon, three-spined stickleback, crayfish or stoneloach were captured during the boat based electrofishing sampling.

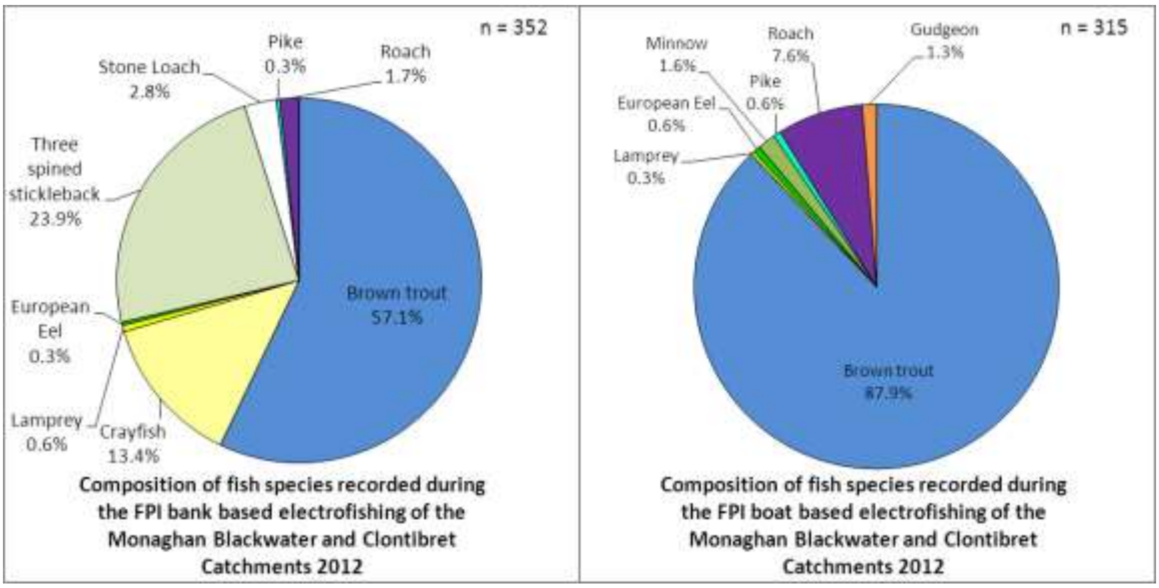


Figure 3.6. Composition of fish species recorded during the Monaghan Blackwater and Clontibret rivers FPI survey using boat and bank electrofishing equipment.

The absence of salmon from the Mountain Water, Monaghan Blackwater and Clontibret Rivers is an anomaly (Figure 3.6). No salmon were recorded in the IFI surveys on the Mountain Water in 1981 and on the Monaghan Blackwater in 1981, 1993 and 1997. As the headwaters of the Mountain Water and Monaghan Blackwater Rivers would appear to have suitable salmon habitat, their absence could be the result of historic impassable barriers since removed through drainage and/or on-going pollution issues.

The fish communities captured during this survey of the Border and Monaghan Blackwater rivers broadly speaking reflect the results of previous studies undertaken by the Central Fisheries Board and IFI. Comparing the fish community recorded during this study with one in 1981 there are two species which appear to be absent from the current FPI study, bream (*Abramis brama*) and rudd (*Scardinius erythrophthalmus*) however, no roach were recorded in the 1981 survey but were in the FPI survey.

Comparing a WFD and FPI site at New Mills Bridge on the Monaghan Blackwater in both cases the 3 most abundant species in descending order were brown trout, gudgeon and stoneloach. The WFD survey also captured minnow, eel and three-spined stickleback in very low numbers which were not captured in the FPI survey. The FPI survey did capture crayfish in appreciable numbers where the WFD survey captured no crayfish, both surveys recorded lamprey.

Length frequency data for brown trout captured between Cappog and Milltown Bridge in 1981, 1993, 1997 and 2012 is shown in figure 3.7. 1981 was pre arterial drainage, while 1993, 1997 and 2012 were post drainage. Post arterial drainage river restoration was undertaken between 1992-1993, in conjunction with the Central Fisheries Board on the Monaghan Blackwater. The length frequency data collected in the 2012 survey represents a river section 19 years post river restoration.

Figure 3.7 shows that there was good recruitment of 1+ trout (14-19cm) in 2012. These 1+ trout have probably not been spawned in this location as there would be a larger proportion of 0+ (<12cm) trout fry captured in all the samples if spawning was a regular occurrence within this site. Therefore, these brown trout must have recruited from the headwater streams to this lower section of the Monaghan Blackwater. The average size of the fish captured in this location is similar for 1981 (26.4cm), 1993 (26.0cm) and 1997 (25.1cm) however in 2012 due to the strong 1+ year class the average size is smaller (20.6cm). Removing this strong 1+ year class the average size returns to 25.6cm in 2012. This shows while brown trout recruitment may fluctuate over the years the channels capacity to support a stable population remains constant.

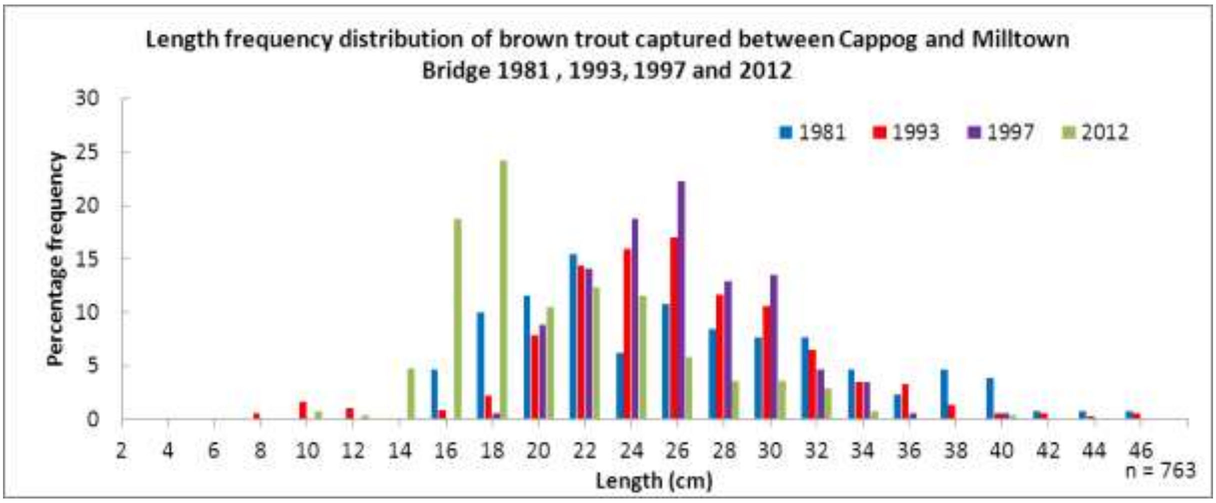


Figure 3.7. Percentage length frequency distribution for brown trout captured between Cappog and Milltown Bridge in 1981, 1993 and 2012.

The FPI survey data coupled with EPA Q-value data and gradient information generated through GIS (Global Information System) software, has highlighted a number of channels suitable for fisheries enhancement through capital works. The Monaghan Blackwater (C1/1/5) upstream of Bellanode village and the tributaries Blackwater (C1/1/5/19), Scotstown (C1/1/5) and the C1/1/5/21 all have sufficient gradient and water quality required for capital works.

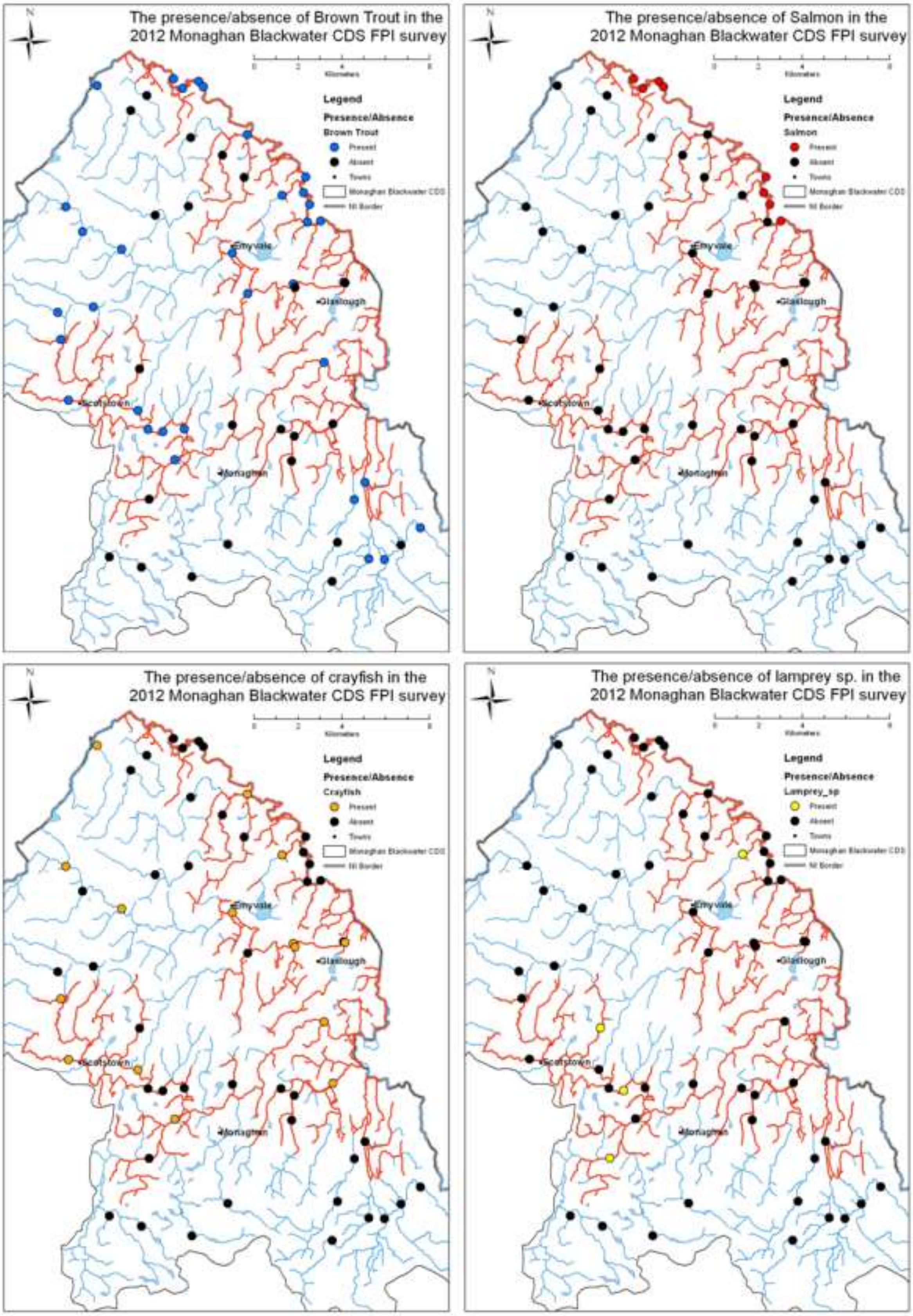


Figure 3.8. 2012 FPI survey showing the distributions of salmon, brown trout, lamprey sp. and crayfish in the Monaghan Blackwater CDS (Blue channels are national rivers; red channels are part of the OPW drainage scheme).

Matt (Bracken) River

The Matt River CDS drains approximately 12.07km^2 and has 15.4km of OPW maintained channel. It is the smallest of the OPW drained river catchments. The two main streams in the Matt catchment are the Matt (also known as the Bracken River) and Tanners stream; both drain two potential National Heritage Areas (pNHA), the Bog of the Ring and Knock Lake. The Matt River discharges through Balbriggan with no discernible estuary.

There are no Q-values available for the Matt River catchment as the EPA has no macro-invertebrate sampling sites. Invertebrate kick samples were taken, in accordance with EPA protocols, during the course of the FPI surveys. Analyses of the 6 kick samples taken during the FPI survey of the Matt catchment gives approximate Q-values of Q2-3 to 3. This result is reflected in the fish community composition (Figure 3.9). Combining fish community composition and the approximate Q-values the Matt catchment probably falls into the "poor status" category for the Water Framework Directive, an "unsatisfactory" condition. The Matt catchment has not been given an EPA ecological status. However in the Eastern River Basin Districts Project 'Final Characterisation' it has been deemed "at risk" from diffuse source pressures, point source pressures and morphological pressures.

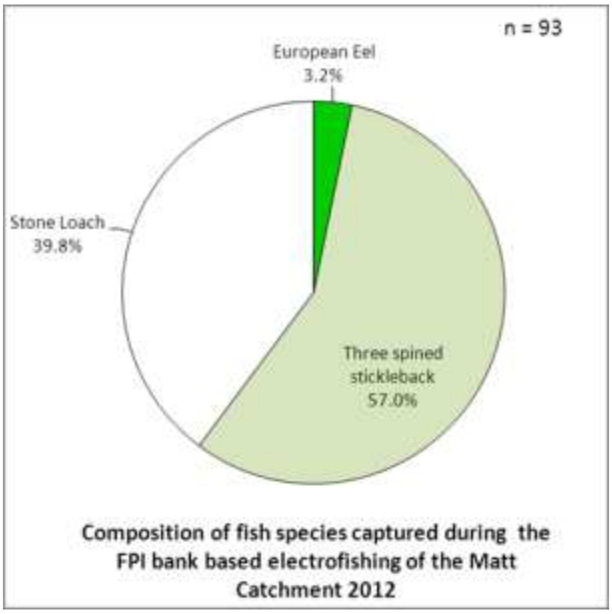


Figure 3.9. Composition of fish species captured in the Matt Rivers FPI survey using bank electrofishing equipment.

Six bank based sites were sampled in the Matt catchment. In decreasing order of abundance, fish species captured during the bank based surveys were stoneloach, three-spined stickleback and European eel (Figure 3.9). Three-spined stickleback were present at each site, stoneloach in half the sites and European eel in two of the sites (Appendix I). The absence of trout from the survey is a concern as salmonids are an indicator of a healthy ecosystem. The absence of trout from the Matt River requires further investigation.

3.2.4 Fish Population Index surveys 2009-2012

Fish population indices reflect many important characteristics of fish species and community's. Length-frequency distribution of the sample reflects population size structure. Numbers of juvenile fish recruiting into the population give indications of spawning success. Quantities of adult and older specimens reflect the carrying capacity of the channel and may indicate possible population and habitat pressures. Analysing the community composition of fish species recorded during these surveys reflects water quality, habitat diversity and other possible pressures effecting the aquatic environment.

The FPI is an excellent fisheries management tool, generating valuable fisheries and ecological data quickly on a large spatial scale. FPI outputs valuable baseline data supplying distribution and density information for aquatic fish species across whole catchments. This data can then be used in screening appropriate assessments and feed into WFD models that will assign status to water bodies using multiple variables including fish species community composition. The FPI data directly feeds into IFI fisheries databases and is then passed on to other government agencies (EPA and the National Parks and Wildlife Service).

The FPI is an extremely useful tool in examining OPW drained river catchments in relation to planning capital works programmes. The FPI, coupled with gradient and EPA Q-value data can be used to highlight areas were capital works will be successful. Examining the population data for salmonid species, it is then possible to tailor capital works programmes to target deficiencies in the population structures. An example would be placing spawning gravel where there is little fry production or the construction of pools where there is a deficiency in nursery and/or adult trout habitat.

In total FPI surveys were undertaken on eight OPW drained catchments between 2009 and 2012 (Table 3.2 and Figure 3.10). This represented a total of 250 fishing events - 197 bank based and 53 boat based surveys, which recorded 9,612 fish, lamprey and crayfish all of which were processed, digitally recorded and analysed.

Table 3.2. The number of FPI survey sites (2009–2012) in OPW catchments (CDS) and regions.

CDS/Region	EAST	SOUTHWEST	WEST
Monaghan Blackwater	59		
Boyle			48
Broad Meadow & Ward	13		
Glyde	39		
Killimor		59	
Deel		17	
Matt	6		
Owenavorragh	9		
Total	126	76	48

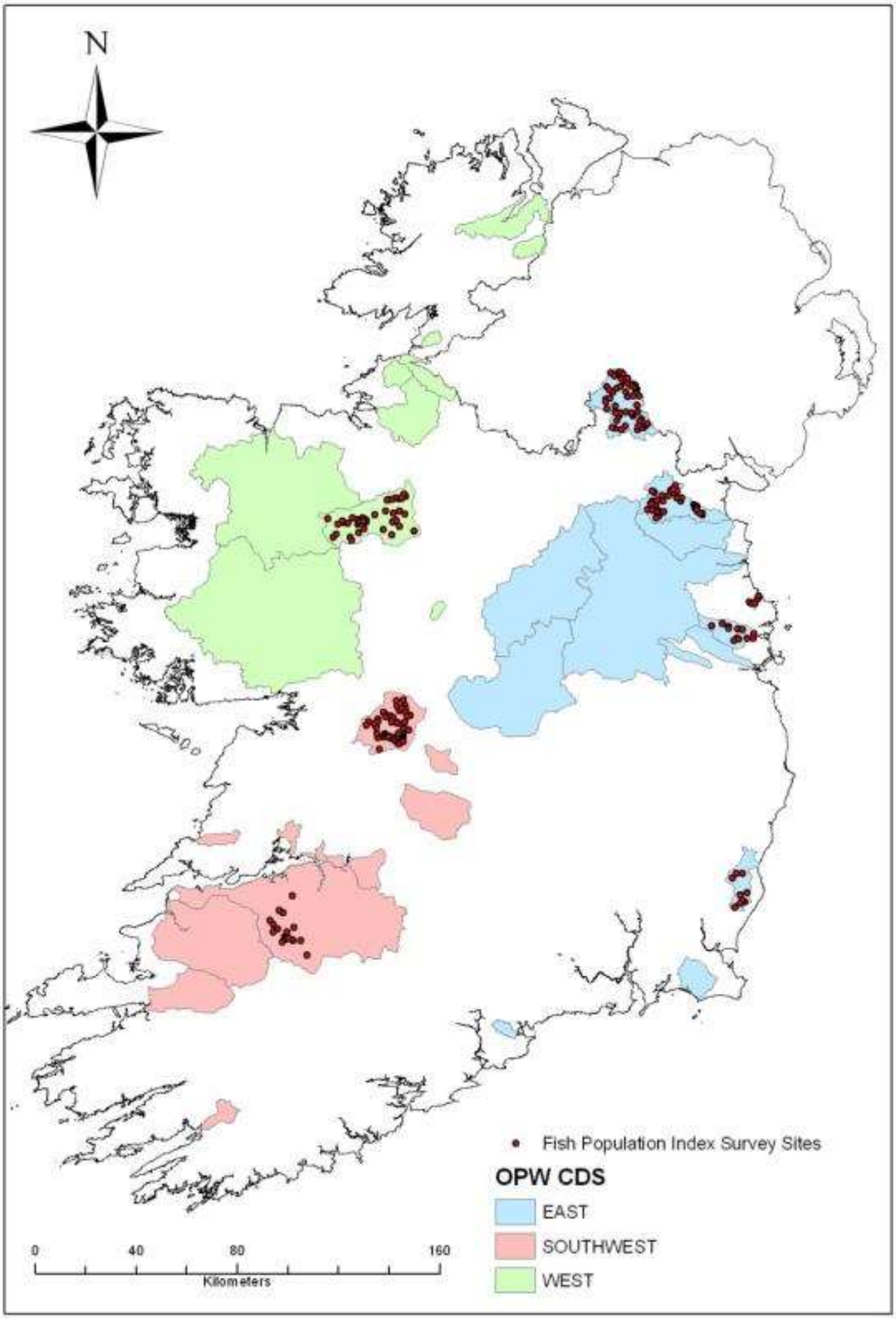


Figure 3.10. Showing the locations of the 250 FPI survey sites completed between 2009 and 2012.

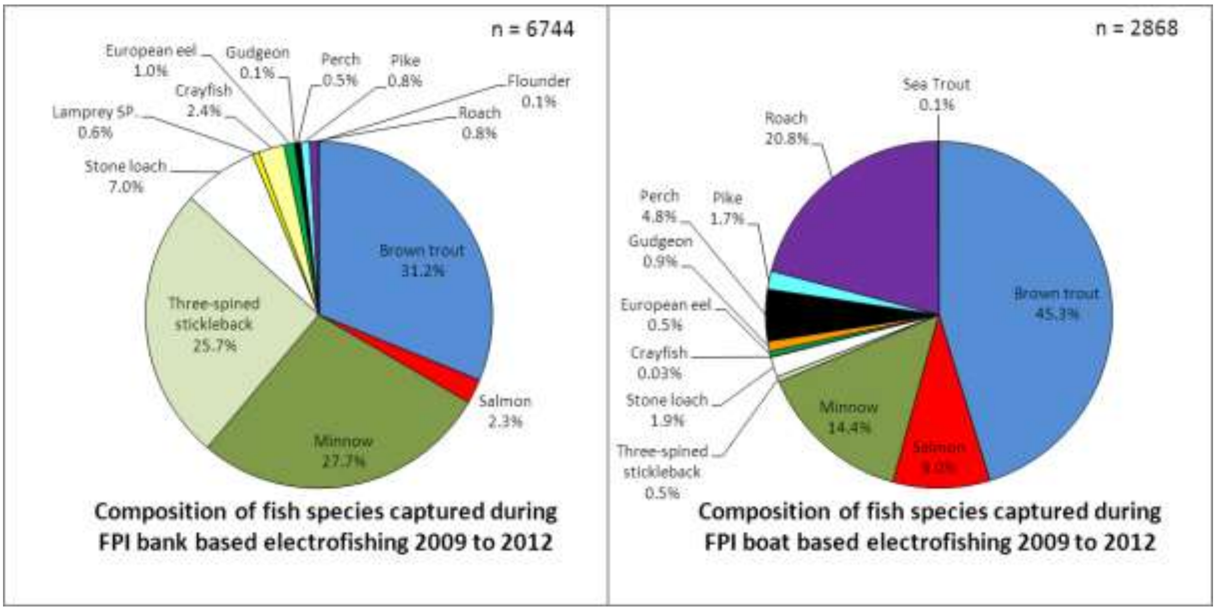


Figure 3.11. Showing the fish community composition of species captured during the boat and bank based FPI surveys 2009-2012.

The composition of fish species captured both in the bank and boat based FPI electrofishing broadly reflects how the different fish species utilise diverse river habitats. Bank based electrofishing surveys shallow (<0.5m) river channels while the boat based electrofishing surveys rivers with greater depths (>0.5m - <3m).

Three examples of how species distribution is effected by habitat types are roach, three-spined stickleback, minnow and trout. The roach's preferential habitat is comprised of deep (>0.5m) slow flowing, lowland rivers and lakes and this is reflected in their abundance in the boat based electrofishing surveys. The three-spined stickleback's preferred habitat is slow-flowing water with areas of emerging vegetation typically, small streams and ditches; this habitat type is surveyed by bank based electrofishing.

Brown trout and minnow distribution is different as they are capable of using more than one habitat type. Both species can be found in brackish water as well as in different types of freshwater, such as streams, rivers, ponds, and large lakes located from coastal areas to high mountains. This ability to uses multiple habitat types is reflected in their high abundance in both the bank and boat based electrofishing surveys.

In decreasing frequency of occurrence species encountered were brown trout, three-spined stickleback, stoneloach, minnow, roach, crayfish, pike, salmon, European eel, lamprey sp., perch, gudgeon, sea trout and flounder (*Platichthys flesus*) (Figure 3.12). Trout were present in 57.9% of sites surveyed; salmon were present in just under 14% of sites (Figure 3.12).

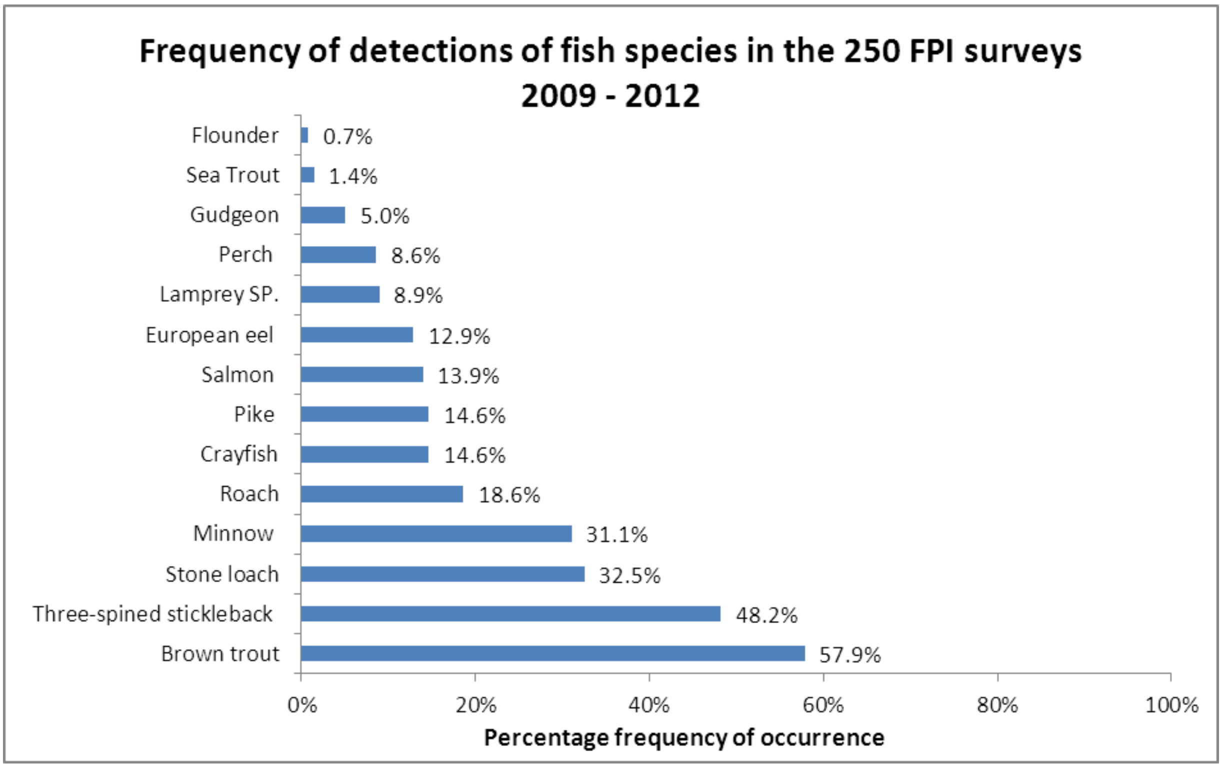


Figure 3.12. Percentage frequency of occurrence of fish species in 250 FPI survey locations between 2009 and 2012 in 11 OPW catchments.

3.3 River Corridor Flora

As a consequence of arterial drainage and on-going channel maintenance, natural processes can be interrupted leading to degraded plant communities. Poor plant communities and as a consequence, poor physical conditions may be just as responsible for restricting biological diversity as poor water quality in many river catchments. With this in mind, the EREP undertook a detailed study of the plant communities occurring within and beside OPW channels from 2008-2012. The main objective of the study was to:

1. Record the plant biodiversity occurring within and beside OPW channels.
2. Assess the impact of channel maintenance on these plant communities.
3. Monitor any changes in biodiversity due to capital works.

3.3.1 Overview

From a plant perspective, OPW channels are relatively diverse with a substantial number of species recorded in general. Overall, a total of 290 (min.=6, max.=62) species were recorded within the riparian/bankside habitat, 75 species in the marginal interface between riparian and aquatic habitat, with a maximum of 27 species at any one site, and 61 species instream, with a maximum of 16 species at any one individual site.

Given the nature of drained channels, there is considerable overlap between species occurring in the marginal zone and instream. For example, club rush (*Scirpus lacustris*) often occurs on the margins and instream of the same channel. EREP was monitoring impacts of works on different habitats. As a consequence of this, species were frequently recorded more than once at a site because it occurred in different habitats. However, purely from a species perspective the site was not anymore species-rich as a result. Combining the marginal and instream species is a better reflection of species richness at a site in a general sense. Therefore, a combined total of 98 (maximum of 29 at any one site) marginal/instream species were recorded overall.

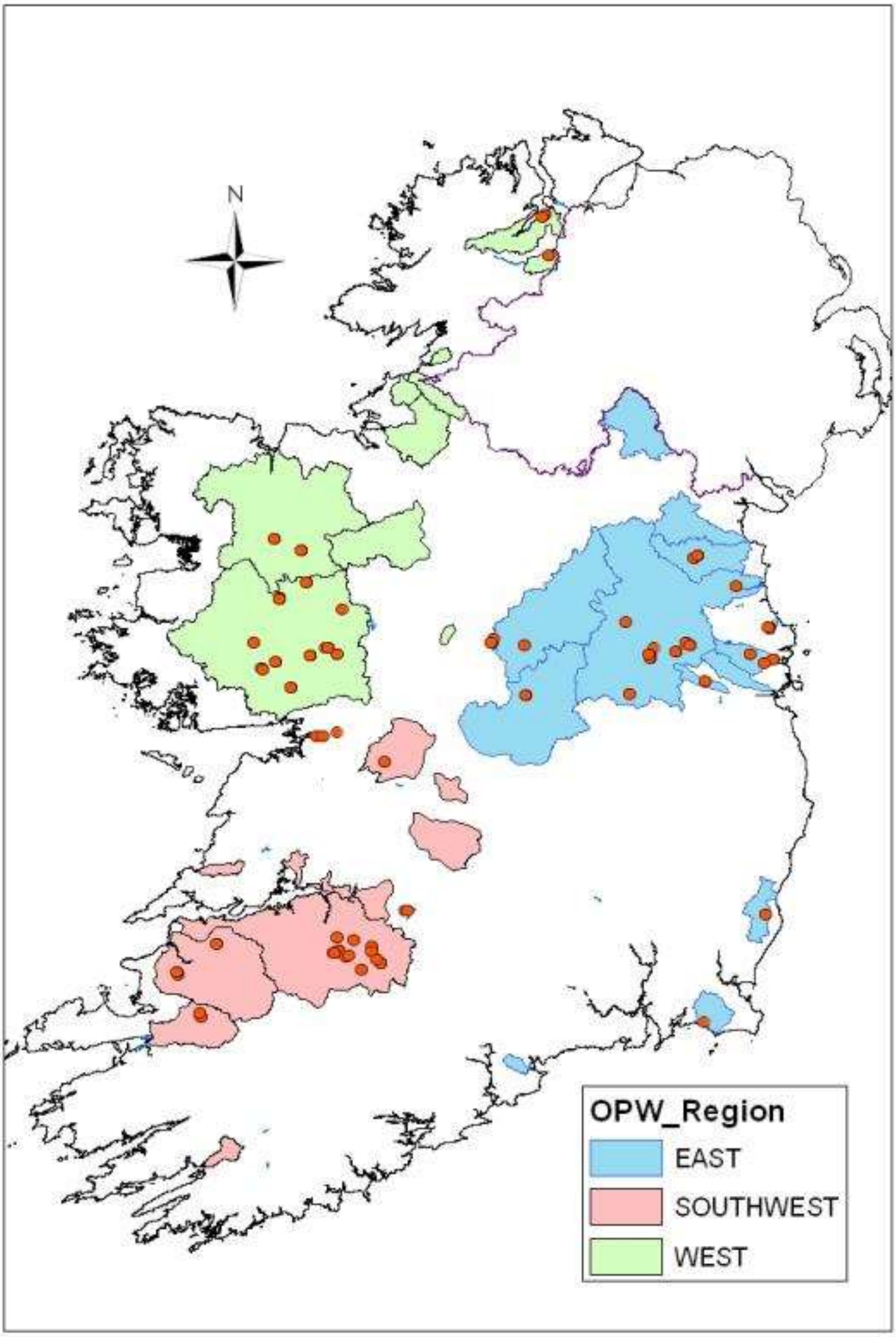


Figure 3.13. Plant survey sites, 2008-2012.

Table 3.3. Species abundance recorded in OPW channels.

Habitat	No. of species recorded
Riparian (n =107)	290
Marginal (n=144)	75
Instream (n=143)	61
Marginal and Instream combined	98

(n= total number of species recorded from all channels surveyed within that habitat type)

There was some variation between habitat types in terms of species abundance (Table 3.3). Some sites surveyed were species rich while others are very poor. Many sites contained no aquatic or marginal vegetation at all. In some cases this is the natural state at the site. For example, where the substrate is mobile gravel, plants may struggle to establish or where there is heavy shade, light can be a limiting factor. In other situations, it is a product of land management. For example, heavy grazing and poaching by livestock can virtually eliminate marginal vegetation. In other cases, all the aquatic vegetation has been removed during recent channel maintenance. Excessive vegetation can also limit species diversity. In some channels, plant species create monocultures across the entire channel and margins, thus excluding other plant and animal species. This is usually a consequence of channel form, where the channel does not have enough energy to limit these species to the margins where they would occur under more natural conditions (Plate 3.1). At the other end of the spectrum, where channel maintenance has been sympathetic or infrequent and overgrazing is not an issue, many channels have renaturalised and contain a good mix riparian, marginal and instream vegetation.

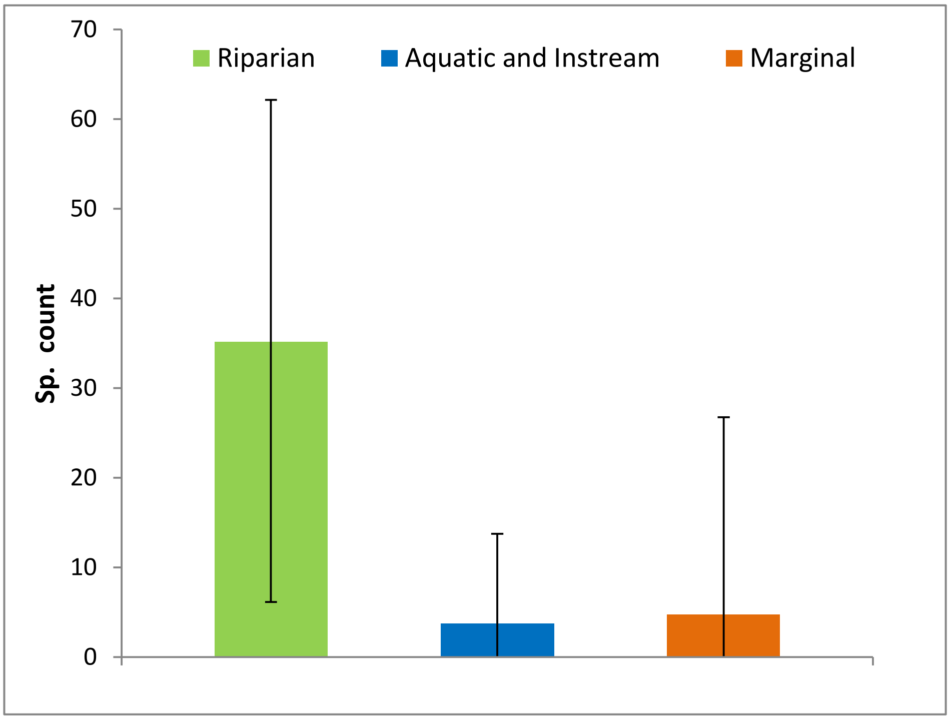


Figure 3.14. Mean species abundance with error bars indicating minimum and maximum values.

Plate 3.1. Channel dominated by a monoculture of water celery.

The vegetation types are also characteristic of a number of botanical habitat classifications. The marginal and riparian vegetation show a good variation in this regard. The instream and tall marginal vegetation are typical of species that occur in depositing lowland rivers. In some rivers in the midlands, extensive reed beds are characteristic of tall herb or large reed/sedge swamps. At other sites, the bankside vegetation reflects that of bogs and fens, while at others it is more typical of dry grassland.

Pre and Post Maintenance

For the purpose of pre and post results, the impacts are discussed in relation to two criteria:

1. Any impact on species presence (with no regard to percentage cover).
2. Any impact on individual species percentage cover (quantitative).

Furthermore, riparian and marginal/instream vegetation are discussed separately. Marginal/instream vegetation was treated as one group in the results and discussion below, unless specifically referred to.

Species Presence

As earlier referred to in the 'overview', the same plant species regularly occur in both the channel margins and instream. On account of this, they were treated as one group in the analyses and discussion below, except where highlighted. Sites were monitored to assess any changes in species present pre and post works.

In general, there was no significant difference pre works and post works (Tables 3.4 & 3.6) in the riparian or marginal/instream vegetation. While the average number of species increased (Table 3.5 & 3.7) post works, this was not great enough to be statistically significant. Depending on the type of works carried out, sites exhibit varying degrees of change post works. On an individual level, some sites were significantly different pre and one year post works, however other sites were unaffected post works. This had a smoothing effect on any statistical analysis and tends to decrease the chance of a significant result when all sites were considered together.

ANOSIM (Analysis of Similarities) is the main statistical test used to compare samples. It is a non-parametric test for assessing any significant difference between two or more groups, based on any distance measure. Bray-Curtis measures, which has been used throughout, measures the percentage difference between samples. In an analogy with ANOVA, the test is based on comparing distances between groups with distances within groups. If the P-value is significant, the groups being compared are statistically different.

Table 3.4. Riparian pre and one year post works.

ANOSIM	P-value
Pre V post +1 (n=10)	0.638 (ns)
Pre V post +2 (n=11)	0.476 (ns)
Pre V post +3 (n=9)	0.525 (ns)

(ns = not significant)

Table 3.5. Riparian mean species abundance pre and one year post works.

	Mean Species No.
Pre	38
Post + 1 (n=10)	47
Post + 2 (n=11)	43
Post + 3 (n=9)	40

Table 3.6. Instream and marginal pre and post works.

ANOSIM	P-value
Post + 1 (n=11)	0.11 (ns)
Post + 2 (n=12)	0.07 (ns)
Post + 3 (n=8)	0.2 (ns)

(ns = not significant)

Table 3.7. Instream and marginal mean species abundance pre and post works.

	Mean Species No.
Pre (n=11)	7
Post + 1 (n=11)	7
Post + 2 (n=12)	9
Post + 3 (n=8)	8

Quantitative

4 sites were surveyed in detail to assess any changes in both species presence and percentage cover. Three sites were heavily wooded and were subject to tree management. The remaining open site was downstream of Hem Bridge on the River Dee (C2). This was subject to extensive capital works which involved pool digging, gravel loosening, deflector construction, log tree revetment, bank re-profiling and fencing.

Wooded

In the wooded sites, there was no significant difference in the riparian species presence or cover pre and post works (Table 3.8 & 3.9). In all three sites, only trees on the working bank were removed in patches, leaving the opposite bank and much of the working bank intact. The increase in available light and space resulted in a rise in species abundance and cover for some species post works. However, plant species already present persisted post works in untreated sections and in some cases established in treated sections. Overall, the level of change detected was not substantial enough to affect a significant change. This is a result of OPW adhering to their own protocols. During channel maintenance on the study sites, the OPW left the non-working bank intact. Sections of the working bank were also left untreated. Ultimately, the outcome was no significant change to the plant species present.

Table 3.8. Wooded riparian sites pre and year post works (n=3).

ANOSIM	P-value
Pre V post +1	0.861 (ns)
Pre V post +2	0.308 (ns)

(ns = not significant)

Table 3.9. Wooded riparian mean species abundance pre and post works (n=3).

	Mean Species No.
Pre	40
Post + 1	46
Post + 2	46

Tree management had limited effect on the establishment of instream or marginal plants. Although some plant species did establish very limited cover one year post works, this was virtually absent two years post works. There were a number of reasons for this. For the most part, the increase in light was insufficient post works to have a substantial impact. In one case, bur reed (*Sparganium* sp.) did establish some cover in the instream channel. This is not desirable species instream from a conveyance perspective and should be confined to the margins where possible.

Open

The banks of the River Dee were heavily poached/grazed and subject to erosion. Four years post works, the banks are stable with tall grass species as the dominant plant cover, a typical situation in non-grazed grassland. An extensive band of emergent vegetation developed on the channel margins, and the relatively diverse instream vegetation remained intact (Plate 3.2). The extent of riparian vegetation was significantly different two and four years post works (Table 3.10). The site was fenced and had its banks re-profiled as part of the works programme. The removal of grazing/trampling pressure and the reshaping of the banks caused changes in the riparian plant community structure. The reshaping of the banks increased the size of the bank face and created a gentle slope for plant species to colonise. The absence of grazing/trampling allowed the bank to fully vegetate, permitting grazing intolerant species to also establish and persist. At the same time, there has been a decline in species number from a peak two years post works compared to four years post works, as the plant community reaches a more stable phase (Table 3.11). The removal of grazing/trampling allowed the more competitive grass species to increase their cover at the expense of other herbaceous plants.

Table 3.10. Riparian pre and post works.

ANOSIM	**P-value**
Pre V post +1	0.458 (sig)
Pre V post +2	0.017 (sig)
Pre V post +4	0.003 (sig)

(sig = significant, ns = not significant)

Table 3.11. Riparian species abundance pre and post works.

	Mean Species No.
Pre	31
Pre V post +1	42
Pre V post +2	58
Pre V post +4	43

Similarly, the exclusion of livestock pressure has allowed emergent vegetation to establish along the margins for years post works (Table 3.14). As well as providing good habitat for number of aquatic and terrestrial insects and animals, it is also offers effective protection against bank erosion.

Table 3.12. Instream pre and post works.

ANOSIM	P-value
Pre V post +1	0.753 (ns)
Pre V post +2	0.345 (ns)
Pre V post +4	0.173 (ns)

(ns – not significant)

Plate 3.2. Pre works (top), one (middle) and four (bottom) years post works.

Table 3.13. Species abundance pre and post works.

	Instream	Marginal
Pre	4	4
Post + 1	6	1
Post + 2	5	9
Post + 3	6	15

Table 3.14. Marginal and instream cover pre and post works.

	% Marginal cover	% Instream cover
Pre	>1	47
Post + 1	>1	47
Post + 2	17	73
Post + 4	100	58

There was no significant change in the instream vegetation post works (Table 3.13). Although there was a slight increase in species recorded, the overall instream cover remains similar four years post works (Table 3.14). Even though capital works improved the hydromorphology of the channel, and this is reflected in the fish surveys, they caused limited changes to instream vegetation. Pre works, conditions were already favourable for the floating river vegetation that is present in the channel. Post works, it remained favourable, and any disturbance of this vegetation during works appears to have been negligible.

Overall, the extensive capital works on this site have proved successful in creating new habitat and species diversity on the margins, maintaining the existing instream plant diversity and stabilising the previously eroding banks.

3.3.2 Floating and Submerged River Vegetation

Watercourses characterised by submerged or floating-leaved vegetation form a priority habitat of international importance, and are listed on Annex I of the European Habitats Directive. The riverine plant communities occurring in the OPW channels are important in a European context and provide examples of the range of river types and variability of associated plant communities. Under the Habitats Directive, the definition of watercourses characterised by these plant communities is very wide. In practice, this covers the majority of rivers and streams with abundant aquatic plant communities, including some emergent species.

Plate 3.3. Floating river vegetation dominated by *Ranunculus* sp. (Mount Nugent, C62) and pondweed (Castlequater/Headford, CH4).

The plant community types can be loosely divided into two groups. Firstly, those that occur on gravel substrate in moderate to fast flowing rivers where *Ranunculus* sp. predominates. Secondly, slow flowing lowland rivers with a stable base flow on a silt or clay substrate where pondweeds (*Potamogeton* sp.) and starworts (*Callitriche* sp.) are abundant. However, elements of each group often occur in the same river, depending on the stretch, their presence or absence dictated by the morphology of individual reaches.

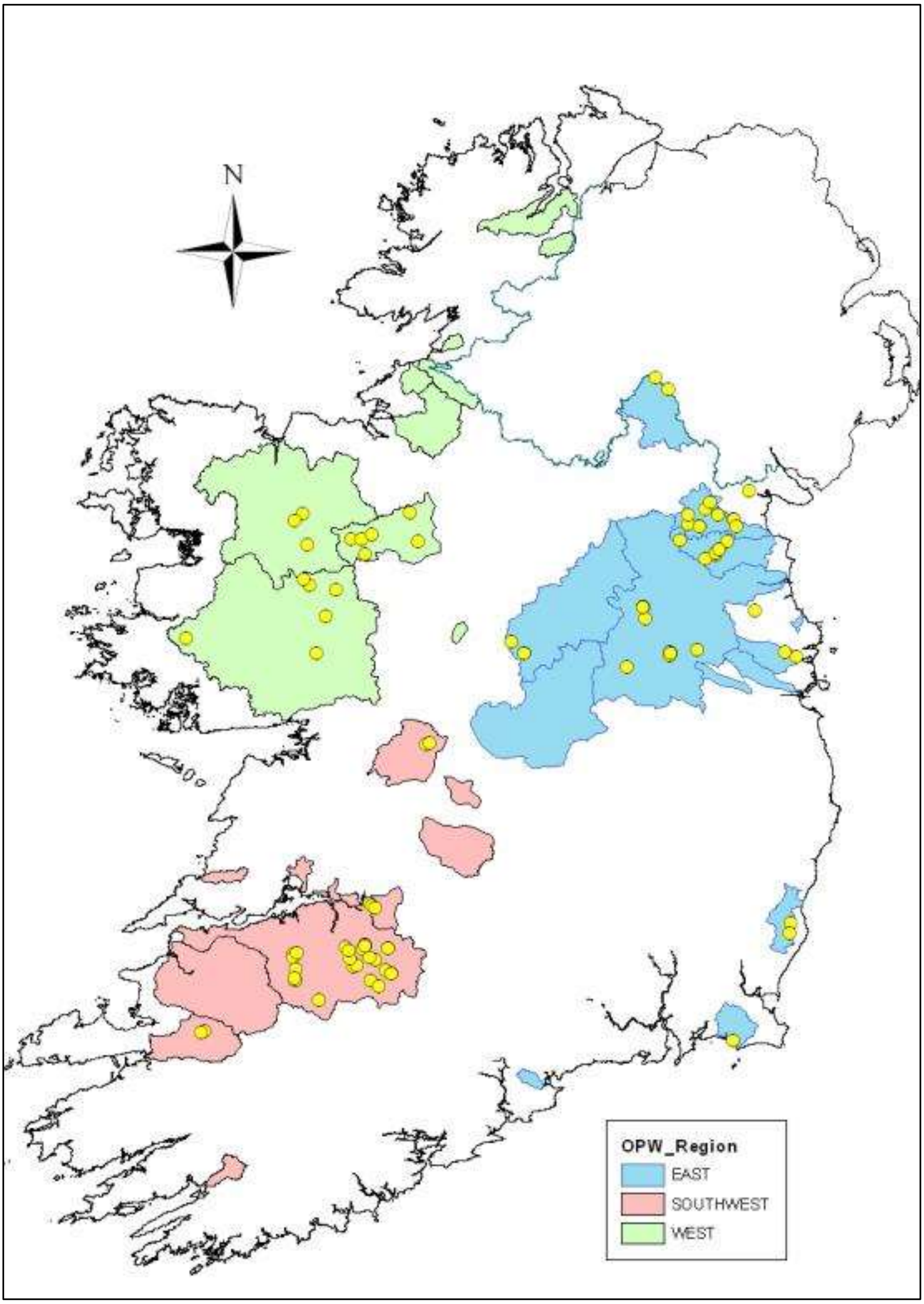


Figure 3.15. *Ranunculus* sp. records, 2008-2012.

Emphasis is often placed on aquatic buttercup species (*Ranunculus* sp.), because of their relative scarcity in a European context. However, aquatic plant species in general are a key component of the physical and biological diversity of channels. Crucially, aquatic plant species are a core factor in providing habitat and food for a range of species, particularly invertebrates and fish.

EREP has been recording the presence of these plant communities since 2008. Data suggest that they are widespread and not infrequent in OPW channels. *Ranunculus* species have been recorded in a number of OPW catchments (Figure 3.15). Overall, their distribution is scattered within catchments, present in some channels, absent in others. Where present, the aquatic vegetation *Ranunculus* is a particularly important ecological component because of the uniform nature of many drained channels. During channel maintenance, care should be taken to minimise disturbance to these plant communities. Stream water crowfoot (*Ranunculus pencilatus)* and wavy leaved pondweed (*Potamogeton crispus)* were the most common species recorded in OPW channels. Both species offer low hydraulic resistance on account of their streamlined morphology (Haslam, 1977 and 1997). From a management perspective, leaving this vegetation in situ will not interfere substantially with hydraulic function; however, its removal represents a considerable ecological loss. Aquatic *ranunuculus* and aquatic plants in general support high densities of macro-invertebrates. They also provide cover and flood refuges for juvenile fish and crayfish. This illustrates the need to maintain diverse plant communities in river channels, and to maximise overall habitat heterogeneity with a mixture of instream/marginal vegetation and banks with trees and open areas.

3.3.3 Sites of high biodiversity value

To the east of Tuam, above Birmingham Bridge lies an area that supports a variety of habitats and species including wet grassland, fen, transition mire and quaking bog. These are listed as Annex I habitats. The site is abundant in orchids (four species), diverse in sedges (11 species) and supports a significant number of other rare or declining plant species. These habitats are now rare in Ireland, as many have disappeared as a consequence of land reclamation, changing agricultural practices and arterial drainage. In common, these habitats and the species that depend on them require moist ground conditions.

The River Nanny (C3/18/1) intersects this site and plays a fundamental role in the continued viability of its habitats and species. The fen habitat present can be categorised as a flood plain fen that is the product of flooding, seepage and spring feeding. As a consequence, any maintenance works should not interfere with this function. Drainage works including widening, deepening and wholesale vegetation removal in 2009 did drop water levels in the river and presumably the local water table. Fortunately from an ecological perspective, recent summers have been exceptionally wet, providing a buffer against any drying out. The river channel itself appears to be recovering with plants re-establishing and some narrowing of the channel taking place. In 2012, 29 marginal/instream plants species where recorded in the channel, many of them infrequent or rare elsewhere in OPW channels. This compares very favourably with an average of 5 species nationally in OPW channels.

Plate 3.4: pre (top left, 2009), during (top right, 2009), one year (bottom left, 2010) and three (bottom right, 2012) years post works.

Devil's-bit scabious (Succisa pratensis) demonstrates the ecological connections between plant species and other wildlife at the site. Devil's-bit scabious which is abundant throughout the site is the food plant of the marsh fritillary butterfly (Euphydryas aurinia). The plant is essential to the survival of the butterfly and study site constitutes optimum habitat for this species. The butterfly has been recorded here on a number of discrete sites in the general area (National Biodiversity Centre) and its presence has also been confirmed on the study site by Butterfly Ireland (Deirdre Hardiman, pers. com, 2012). The marsh fritillary is the only Irish insect listed on Annex II of the European Habitats Directive. It is a colonial butterfly with most individuals remaining in discrete patches of habitat. The site around the River Nanny is ideal habitat. Colonies need a sufficient area of habitat so that the species can survive natural habitat change and the effect of parasites. Individual sites are thought to exist as part of a network of neighbouring sites that are used periodically as conditions permit. If the habitat patch is large enough, colonies may persist for many years. Bearing this is in mind, any maintenance works that have a deleterious impact on its habitat will have a knock on effect the species itself.

We strongly recommend that there should be no future channel maintenance upstream of Birmingham bridge that involves a digging machine for the following reasons:

- Any machine that tracks in across the site will damage the habitat and its constituent flora.

- Any spoil dumped on the bank will have the same impact

- Any change to the water table has a potential negative landscape impact on Annex 1 habitats

- The river channel has taken three years to show signs of recovery and will require a few more years for the plant community to fully recover. The bucket on a digging machine is not precise enough to limit damage to specific plant species.

3.4 Bird Population studies

Bird surveys of river corridors began in 2009 and continued in 2010, 2011 and 2012. The key objectives were as follows:

1. Record the abundance, species richness and distribution of bird species in OPW river corridors.
2. Assess the impacts of drainage, drainage maintenance and capital work programmes on bird species based on this data.

To this end, surveying was conducted on:

- 500m sections of channel defined by habitat type.
- 500m channel sections pre and post channel maintenance/works.
- Mixed habitats over a 5km channel section.
- Undrained channels to compare with drained channels.

In 2012, eight channels were surveyed (Table 3.15) including two undrained rivers, using the 500m methodology (2009 EREP Annual Report). In addition to these, four channels were surveyed in a canoe over a distance of 5km (Appendix II). These are discussed later.

Table 3.15. Sites surveyed in 2012.

River	*Channel Code*	*Drained/Undrained*	*500m*	*5km*
Glore	C1/30	Drained	✓	
Boyne	C1	Drained	✓	✓
Enfield Blackwater	C1/36	Drained	✓	
Finshenagh	C1/17	Drained	✓	
Clonshire	C1/17	Drained	✓	
Robe	CM4	Drained	✓	✓
Deel	C1	Drained		✓
Suir		Undrained	✓	✓
Bride		Undrained	✓	

3.4.1 Habitats

The influence of habitat type on bird and species abundance was one of the key findings of the bird surveys from 2009 to 2011 (IFI, 2011). Following baseline surveys in 2009, three distinct habitat types were identified within the river corridor:

1. Open: cropped or low growing bankside vegetation, often a result of livestock grazing.
2. Treelined: sites often consisting of a mix of mature trees and underlying scrub.
3. Heavy marginal: sites with tall emergent vegetation growing along the banks.

The main findings were as follows:

- Treelined sites supported the most bird species and bird numbers, marginal sites the second most and open sites supported the least.
- These findings were common to drained and undrained sites

A total of 15 drained and 16 non drained channel sections were compared. These sites represented the three habitat types. Multivariate analysis indicates no significant differences in the bird communities recorded on arterial drained channels and undrained channels (Table 3.16) (IFI, 2012).

Table 3.16. Results comparing 15 drained and 16 undrained channels.

Analysis of Similarity Test (ANOSIM)	**P-value**
Drained V Undrained	0.85 (ns)

(ns = *not significant)*

The value of trees and the habitat heterogeneity they provide for bird species was reflected in the survey results from 2009 to 2011. The value of treelined channel sections cannot be overstated given the absence of tree cover over substantial areas of Irish arterially drained catchments. The same is true of tall marginal vegetation which provides cover, nesting areas and food for truly riverine bird species. Whereas trees are present in hedgerows, wooded areas, parkland etc, tall marginal vegetation is often scarce given the relatively limited area that rivers occupy and the pressures on rivers from livestock and land management. Species ranging from reed buntings to waterfowl are indicative of this habitat and are absent in the river corridor landscape where this habitat does not exist. It is therefore essential that OPW maintenance is sympathetic in its management of this habitat type. Maintenance works that encourage a mosaic of habitats and associated micro-habitats can provide diverse conditions likely to increase diversity of not only birds, but a range of biota.

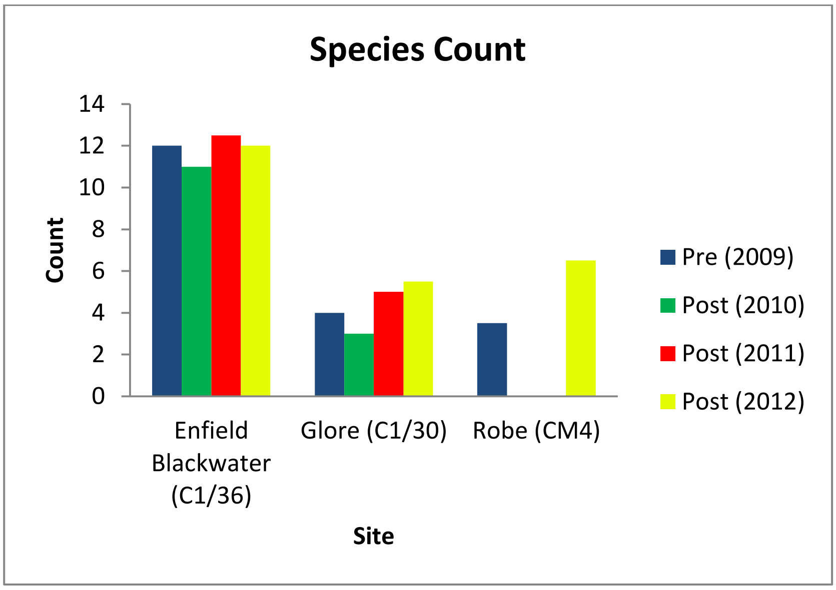
The type of survey methodology and analysis employed demonstrates only:

- That there were no significant differences between undrained channels and drained channels in general.

This may not apply on the species level where some birds have very specific requirements e.g. dippers (*Cinclus cinclus*) need riffle areas, often scarce in drained channels, or kingfishers (*Alcedo atthis*) use overhanging branches that can often be removed during channel maintenance. A species specific survey methodology would be necessary to investigate properly if any significant differences exist between drained and undrained channels regarding a particular species.

3.4.2 Pre and Post works monitoring

Three channels were surveyed pre works in 2009, two channels post works in 2010 and 2011 and all three again post works in 2012 (Figure 3.16). It was felt that three years post works was a reasonable gap to assess the medium term impact of channel maintenance. As a result of works on the Glore (C1/30, Moy) and the Robe (CM4, Corrib) rivers, there was extensive loss of marginal vegetation and the Enfield Blackwater (C1/36 Boyne) had substantial tree removal. Immediately post works, this scale of habitat loss constituted a large disturbance to the bird community.



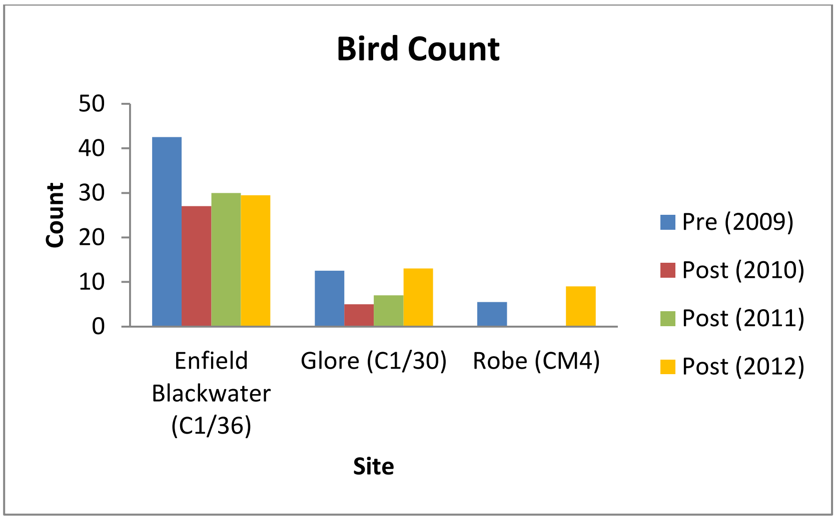


Figure 3.16. Species (top) and bird abundance pre (2009), one year (2010), two year (2011) and three years post (2012) works. Note: no data was available for the Robe in 2010 and 2011.

Table 3.17. ANOSIM results pre works (2009), one year (2010) post works and three years post works (2012).

ANOSIM	P-value
All Pre (2009) V Post (2010)	0.05 (sig)
All Pre (2009) V Post (2011)	0.14 (ns)
All Pre (2009) V Post (2012)	0.02 (sig)

(ns = not significant; sig = significant)

Individual bird and species abundance decreased in the Glore and Enfield Blackwater rivers one year post works (Figure 3.16). Species abundance was equal or greater three years post works in 2012. Bird abundance increased in the Glore and Robe, but was lower in the Enfield Blackwater three years post works. Analyses of survey data using a multivariate test showed significant differences in the bird community one years and three years post works (Table 3.17). Although the P-value was not significant two years post works, where P = 0.14, it still suggests considerable variation in the bird communities between years.

This is evident when sites were further analysed using Bray Curtis similarity indices (Table 3.18). Bray Curtis is also termed the percentage difference, and calculates the level of dissimilarity or similarity between predefined groups. Here, the results are presented as the percentage similarity between groups. The higher the percentage score, the more similar the groups are. The data suggest that channel maintenance where the marginal or treeline vegetation is severely impacted results in noticeable changes in the bird community.

Table 3.18. Bray Curtis indices comparing percentage similarity pre works (2009) and post works (2010-2012).

Site	2010	2011	2012
Enfield Blackwater (C1/36)	50	37	43
Glore (C1/30)	19	33	26
Robe (CM/4)	n/a	n/a	14

3.4.3 Undrained Channels

Undrained channels were examined for control purposes in 2010, 2011 and 2012 for comparison with recently maintained OPW channels. Two undrained channels have been repeatedly surveyed between 2010 and 2012 for this purpose. This was undertaken to determine:

- Do bird populations fluctuate within non drained channels?
- Are population fluctuations within drained channels a result of channel maintenance or natural variation?

Possible impacts on waterway species from drainage include the removal of habitats for nesting and feeding opportunities, both instream and in the riparian zone. Marginal vegetation also serves as a refuge from predators. The removal of this vegetation may lead to changes in species composition and abundance within a channel, thus resulting in potential differences between drained and undrained channels.

Whilst it may seem likely that drainage maintenance may impact upon the abundance and distribution of waterway bird species, such practices are not likely to be the sole cause of changes in population dynamics. The wide-ranging fluctuations in abundance and species richness depend also on factors such as seasonal migrations, food availability, weather, water levels, agricultural land management and other anthropogenic influences. In order to further develop drainage maintenance policies which are considerate of waterway bird species, bird populations in undrained channels are discussed with reference to recently maintained drained channels in the section above (pre and post monitoring, section 3.4.2).

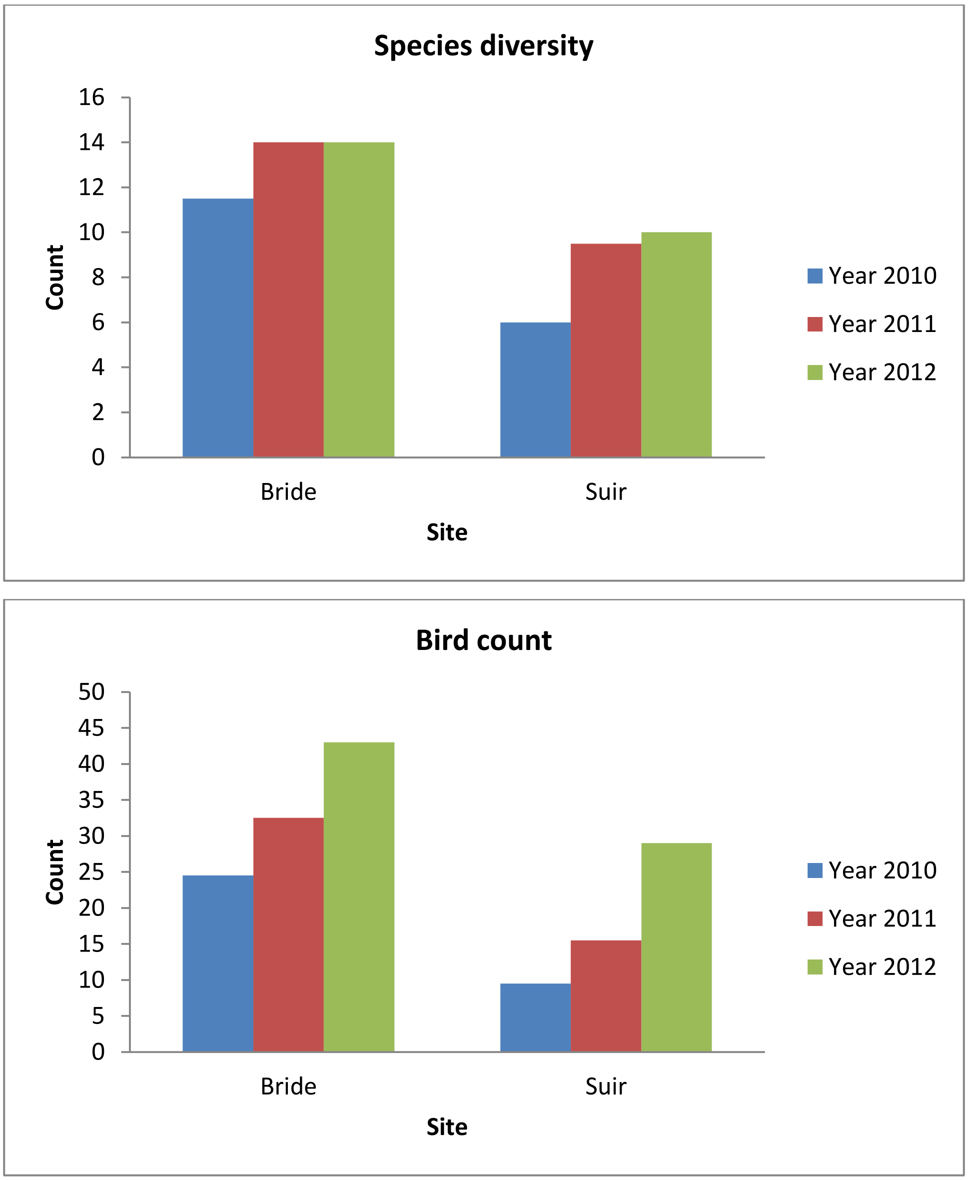


Figure 3.17. Species diversity (top) and individual bird counts (bottom) from each of the undrained rivers, 2010-2012.

Table 3.19. ANOSIM results of undrained channels (R. Bride and R. Suir) between years 2010-2012.

ANOSIM	P-value
All (2010) V Post (2011)	0.87 (ns)
All (2011) V Post (2012)	0.73 (ns)
All (2010) V Post (2012)	0.53 (ns)

(ns = not significant)

Table 3.20. Bray Curtis indices comparing percentage similarity between years in undrained channels (R. Bride and R. Suir), from 2010 to 2012.

Comparison	% similarity
Bride 2010 with Bride 2011	53
Bride 2011 with Bride 2012	61
Bride 2010 with Bride 2012	53
Suir 2010 with Suir 2011	37
Suir 2011 with Suir 2012	42
Suir 2010 with Suir 2012	33

In common with drained channels the survey results suggest that there is variation in-between years in the bird population of undrained channels (Figure 3.17). This is supported further when the results are analysed using the Bray Curtis similarity indices (Table 3.20). In contrast to the drained channels (Table 3.17), there was no significant difference in the bird community of undrained channels between years (Table 3.19). The ANOSIM statistical test takes account of both bird abundance and species composition. This accounts for the difference in statistical significance between drained channels subject to recent maintenance and undrained channels. When analysed together, the species composition and bird abundance was significantly different pre works and post works in the drained channels. This was not the case in the undrained channels.

5km Surveys

Following the use of canoes for bird surveys by BirdWatch (BWI), EREP adopted this technique in 2012. This was to ensure that EREP and BWI data were comparable for future use. The obvious advantage of the canoe is that greater distances can be covered over a shorter time period. This method is particularly useful on larger rivers.

Using the canoe, 4 channels were surveyed over a distance of 5 kilometres in 2012. These surveys allowed EREP to test the effectiveness of the 500m methodology in identifying the bird community/species richness associated with a particular channel. This is particularly important when recording species that have large ranges such as the kingfisher (range of up to 5km). These species can be missed using the 500m methodology.

In common with the 5km survey results from 2011 (collected on foot), substantially more species were recorded using the 5km methodology (Table 3.21). An average of 28 species were recorded using the 5km approach, compared to 5 species using the 500m methodology in 2012. The results demonstrate that the 5km approach provides more comprehensive data on the bird species occurring along the river corridor. It is also likely to be more effective at sampling species that have large ranges.

The results are as expected, with more species being sampled using the canoe. A larger survey area will sample a larger numbers of species, and larger numbers of individuals, on account of the greater variety of habitats and feeding opportunities available sampled.

Table 3.21. Species abundance recorded in 2012 using the 500m and 5km methodology.

Channel	**500m**	**5K**
Boyne	8	37
Suir	5	23
Robe (CM4)	2	24

3.4.4 Additional Bird Sightings

The 'Additional Bird Sightings' database involves recording all bird species observed in the river corridor outside the formal line transect surveys, together with associated GPS locations and dates. A large number of IFI staff both within and outside the EREP project, contributed to the data recorded during field work to this database.

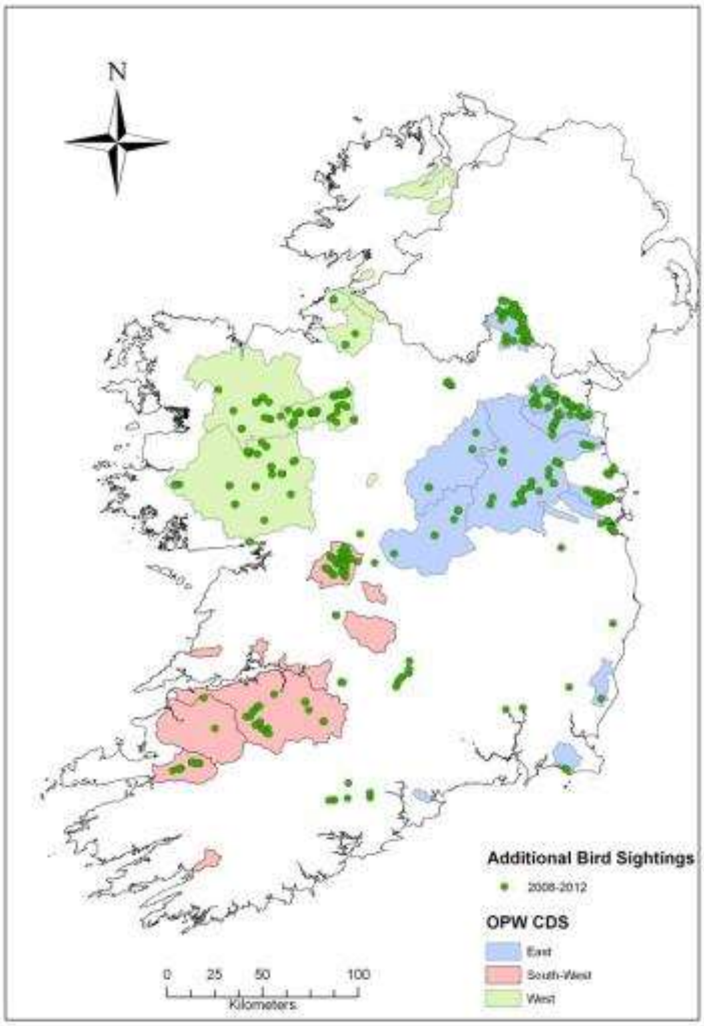


Figure 3.18. Locations of the 2008-2012 EREP additional bird sightings.

This data allowed a more accurate illustration of species richness in channels as it was not restricted to either specific breeding seasons or time of day. For instance, only 26 kingfishers were recorded during the formal 500m and 5km line transect surveys from 2008-2012. However, using this supplementary survey, an additional 103 kingfishers were recorded in across 35 OPW drained and 15 undrained catchments. This gives a more accurate representation of kingfisher distribution within Ireland (Figure 3.19). A similar situation occurred with the dipper; with only 6 birds being recorded during 96 formal line transect surveys. These birds were identified solely in undrained rivers. However, when the 'Additional Bird Sightings' database is taken into account a further 36 dippers were recorded, of which 26 were found in 14 drained channels.

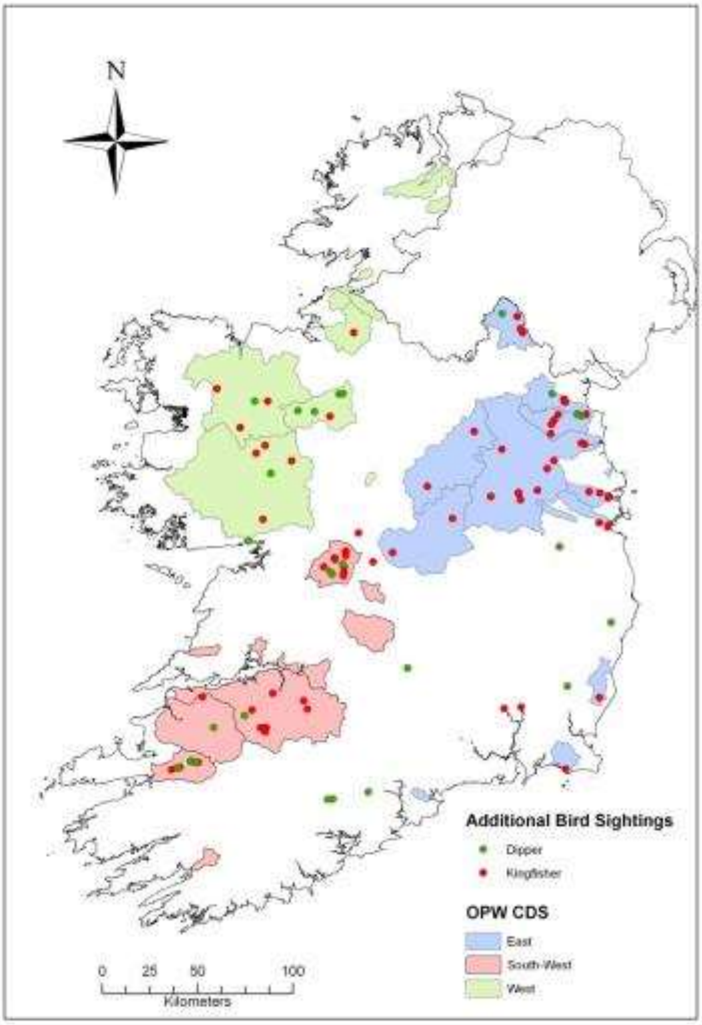


Figure 3.19. Locations of the 2008-2012 EREP kingfisher and dipper additional bird sightings.

This database also provides data for catchments, such as the Maine and Boyle, in which no formal line transect survey have been undertaken, thereby augmenting the EREP riparian bird species database. Overall, a total of 75 bird species, such as the moorhen, wren (*Troglodyes troglodytes*) and redshank (*Tringa totanus*), were recorded in the 'Additional Bird Sightings' database along river corridors.

Since its incorporation into the EREP sampling methodologies, in 2009, the 10 minute Fish Population Index (FPI) survey has proved an invaluable tool in the collection of riparian bird data. This catchment wide survey rapidly and efficiently increases riparian bird knowledge in catchments where little or no recent data was available to EREP. Figure 3.20 shows the location of all additional sites where information was collected. In total 92 bird species have been recorded.

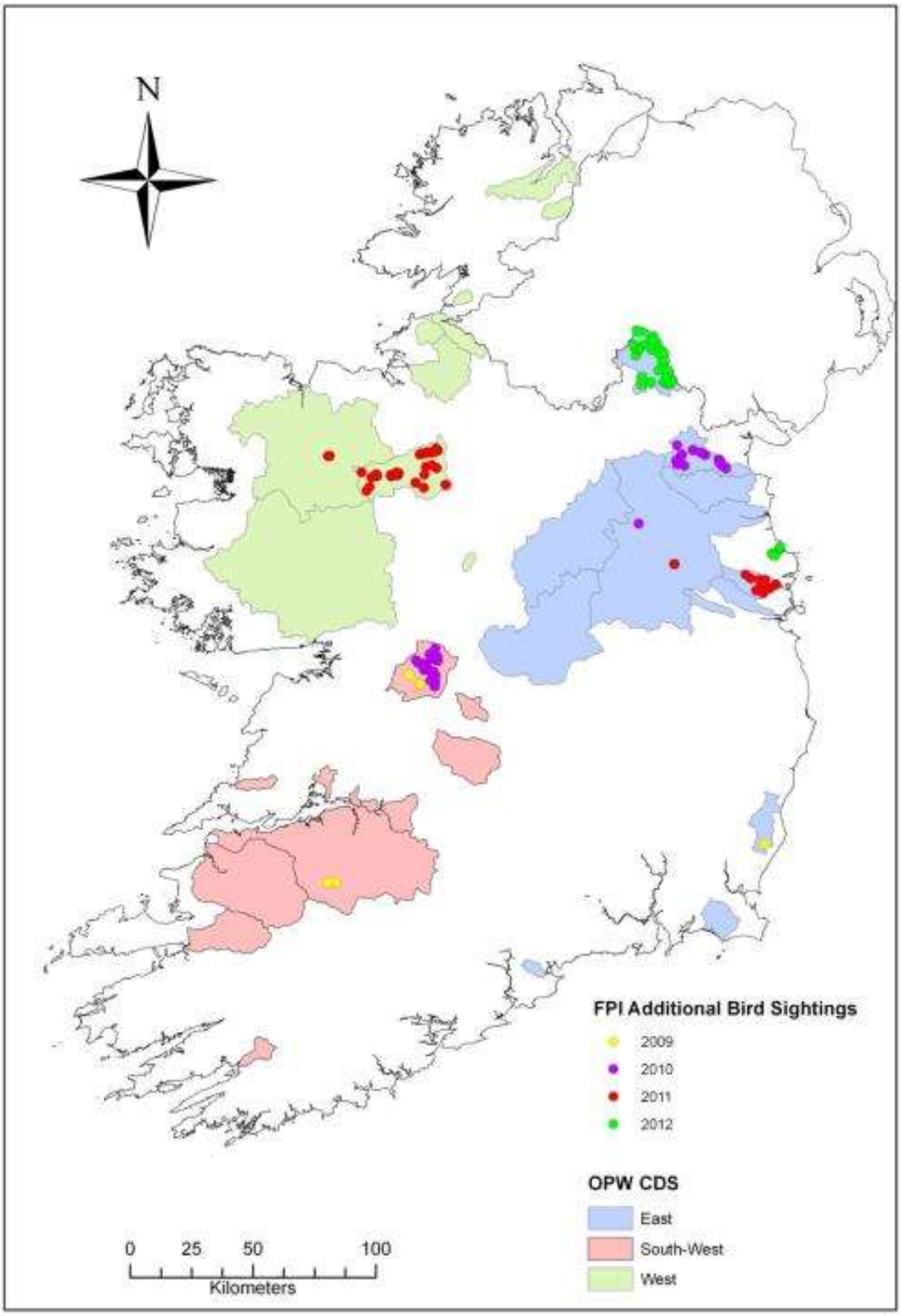


Figure 3.20. Locations of the 2009-2012 FPI additional bird sightings.

3.5 Macro-invertebrate Monitoring

3.5.1 Aquatic Macro-invertebrate Monitoring

EREP undertook macro-invertebrate sampling from 2008-2012. The objective of this study was:

1. To record aquatic macro-invertebrate biodiversity in OPW channels.
2. To assess changes in the aquatic macro-invertebrate community following channel maintenance and capital enhancement works.

To this end, a species database was set up and a selected number of channels were monitored for macro-invertebrates pre and post enhancement works.

All samples were identified to the lowest taxonomic level suitable to assess change in the macro-invertebrate community and for water quality assessment, in accordance with EPA guidelines. Following identification, taxa were allocated to their functional feeding group (Moog, 2002). The purpose of this was to show changes in community composition that could be a reflection of the OPW's instream works e.g. changes to the substrate or riparian vegetation stands may affect the number of shredders and grazers present in a site.

In total 117 genus/species were identified that fall within 92 families (it was only possible to identify some to genus level). Species recorded occupied a variety of niches and represented almost all functional feeding groups, including grazers, predators, shredders (of leaf material), filter feeders and many more.

Broadly speaking, the main OPW activities undertaken and likely to have impacted on the macro-invertebrate community were tree management and instream development works – specifically;

- Tree cutting increases plant cover as a product of more available light, hence, better growing conditions for some plant species.
- The creation of pools and riffles through digging increases habitat diversity (Plate 3.7).

Sites were monitored and statistically analysed where these types of channel works took place.

Note: the impact of instream works and tree management on macro-invertebrates in specific sites have been discussed in previous EREP reports to OPW (IFI, 2009, 2010, 2011 & 2012).

3.5.2 Results and Discussion

Firstly, sites were analysed for any taxonomic differences pre and post works. Three similar sites subject to tree management were examined for any difference one year post works. Despite an increase in macro-invertebrate density, there was decrease in species abundance in all sites one year post works (Figure 3.21). However, this had no significant difference on species abundance or macro-invertebrate density (Table 3.22).

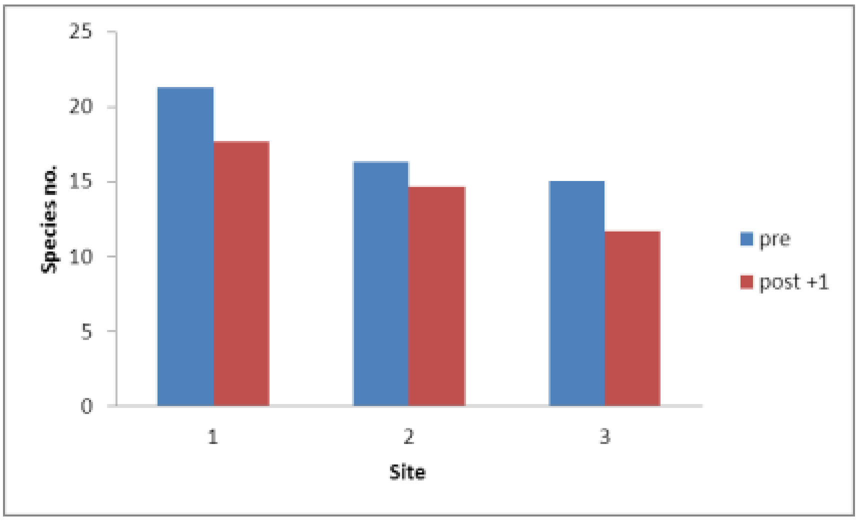


Figure 3.21. Mean macro-invertebrate species abundance pre and one year post works.

Two sites were examined two years post works. Site 1 had deflectors, pools and a riffle area constructed. Site 2 had pools excavated and tree management. Although there was a small increase in species abundance and some increase in macro-invertebrate density (Figure 3.22), this had no significant impact (Table 3.22).

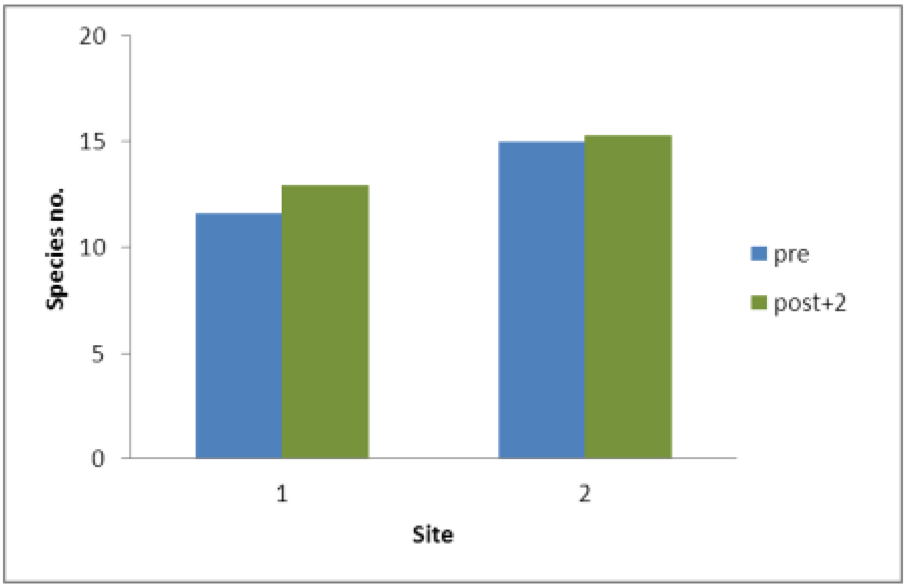


Figure 3.22. Mean macro-invertebrate species abundance pre and two years post works.

Table 3.22. Pre and post works, assessed for differences in genus.

ANOSIM	P-value
Pre V Post +1 (n=9)	0.151 (ns)
Pre V Post +2 (n=6)	0.108 (ns)

(ns = not significant)

Secondly, sites were analysed for any differences in the functional feeding groups' pre and post works. For example, removal of trees can impact on the availability of leaf litter for shredders. No significant difference was found in species abundance or macro-invertebrate density (Table 3.23).

Table 3.23. Results pre and post works, assessed for differences in functional feeding groups.

ANOSIM	P-value
Pre V Post +1 (n=9)	0.128 (ns)
Pre V Post +2 (n=6)	0.21 (ns)

(ns = not significant)

Finally, sites were analysed for any differences in specific functional feeders' pre and post works. For example, one group that can benefit from creation of riffle areas or tree cutting is grazers. Twenty five species of grazers were sampled in the sites under investigation. However, no significant change was recorded in species abundance or macro-invertebrate density (Table 3.24).

Table 3.24. Results pre and post works, assessed for differences in grazers.

ANOSIM	P-value
Pre V Post +1 (n=9)	0.059 (ns)
Pre V Post +2 (n=6)	0.42 (ns)

(ns = not significant)

Despite an increase in macro-invertebrates density in all the sites analysed, this did not prove to be statistically significant. There may be a number of reasons for this result. The first is a common occurrence when analysing large data sets with a high number of species. For a significant statistical result to occur, the difference pre and post works must be profound. The type of monitoring and analysis undertaken cannot detect moderate changes in the biological community. For significant changes to be detected, it is necessary to concentrate on specific species and to undertake a sampling strategy and analysis that reflects this. However, as a matter of practicality, EREP was limited to general impacts on the biological community as a whole.

Plate 3.4. River Robe (CM4) pre works (top) and completed riffle following capital works (bottom).

It is also probable that the level of tree cutting was not substantial enough to affect a dramatic change in the macro-invertebrate community, especially given the wet summers of recent years. Indeed, the high water flows have a similar impact on riffle areas and tree managed sites with regard to macro-invertebrates. One effect of riffle area creation is that it raises the river bed closer to the water surface, thus, increasing light availability and plant growth, as does tree management were it creates gaps in the canopy. However, the wet summers of recent years have negated this effect on a number of counts. Firstly, by submerging the riffle areas, secondly, by making the water turbid and thirdly by increasing water velocity and depth. High velocities increase turbidity which reduces light penetration and plant growth a result. High velocities and increased depth also make it is difficult for plant species to establish. In turn, poor plant growth or establishment limits the number of macro-invertebrates that can survive in a given site. Previous research has shown that riffles become ecologically ineffective for macro-invertebrates species typically associated with that habitat when the depth is greater than 30 cm (Ebrahimnezhad and Harper, 1997; Harper *et al.*, 1998).

3.6 Physical Monitoring

The importance of physical habitat in determining the condition of the river ecosystem is implicit in its definition, because without a suitable 'living space' a given species is unlikely to exist at that particular location (Maddock, 1999). River channels are made up of structural features (e.g. channel size, channel shape, gradient, bank structure, substrate size). When these features are combined with a particular discharge level, a distinct pattern or mosaic of hydraulic features (depths, velocities, and shear stresses) is produced. It is a combination of these two attributes that make up the physical habitat.

Channel modification has been both widespread and intensive as streams and rivers have been aligned for farming convenience, to aid navigation, to achieve the engineering objectives of flood alleviation and agricultural drainage or straightened adjacent to roads and railways. As a consequence, many rivers have a `channelized' nature with straight, trapezoidal channel sections and uniform bed morphology.

Techniques used in the EREP programme such as recreating pools and riffles, reinstating sinuosity inside straightened reaches, artificially narrowing over-wide channels and placing structures in the bed are used to recreate natural forms of a rivers morphological diversity. Recreating a river's natural morphological diversity involves reinstating the rivers physical habitat and in doing so greatly increasing the 'living space' available to aquatic organisms.

The EREP physical monitoring programme has systematically surveyed 8 sites utilising the Before-After-Control-Impact (BACI) experimental design method (Table 3.25). Engineering levelling instruments were employed to measure long and cross sections, electromagnetic flow meters were used to measure water velocities and water depths were taken systematically throughout using a grid method.

Table 3.25. EREP physical surveys their location, work type and survey type.

Location	System	No. of Sites	Works Type	Survey Work
Dee	Glyde and Dee	2	CW	LS, CS
Enfield Blackwater	Boyne	3	CW	LS, CS, Depths, Velocity Readings
Maine	Maine	2	CW	LS, CS, Depths
Deel	Deel	4	EM	CS, Berm Mapping
Morningstar	Maigue	2	CW	LS, CS, Velocity Readings
Camogue	Maigue	2	CW	LS, Depths, Velocity Readings
Robe	Corrib	2	CW	LS, CS, Velocity Readings
Colemanstown	Corrib	1	EM	LS

LS = Long Sections, CS = Cross Sections CW = Capital Works, EM = Enhanced Maintenance

Reviews of physical works and its effect on fish, plants and macro-invertebrate communities for the River Dee, Enfield Blackwater, Maine, Deel, Morningstar, and Robe River can be found in previous EREP annual reports (IFI, 2009, 2010, 2011 & 2012).

It is noteworthy that all of the decompacted gravel beds and introduced gravel spawning shoals used in the capital works sections have been used by salmonids for spawning purposes.

Reviewing capital works sites which were not monitored, it was observed that all structures are in place and functional. There has been no catastrophic failure of any structure constructed under the capital works programme of EREP. An initial issue of sourcing correctly sized gravels for spawning beds has been rectified, preventing erosion of these beds in flood flows. However, structures constructed through the capital works programme and excavations undertaken through enhanced maintenance are in a dynamic environment. Structural failure or infilling of features is always a possibility due to natural forces outside the control of IFI or OPW.

3.6.1 River Maine

The River Maine discharges into Castlemaine Harbour at the head of Dingle Bay. The experimental works site is straddling the town of Castleisland and extends from the bridge at Tullig (B118) to 'The Farmers Bridge' (B8) downstream of Castleisland. In total ~1.2 km of channel was enhanced in this capital works programme. Between 2009 and 2013 the capital works programme has been extended upstream and downstream of the initial works programme. For a full review on the effects of capital works on the fish community, within this section, see the EREP annual review 2011.

Physical Survey

The physical survey was repeated in 2012 giving a time series of pre works in 2009 to post works in 2010, 2011 and 2012. Long sections were taken using an engineering level and water depths were taken systematically throughout using 5 meter cross sections.

The bed material is predominantly composed of large gravels and cobble, which is mobile in high flow conditions. This material has filled in some of the pools and thalweg created during works in the experimental site. This can be seen in the long sections (Figure 3.23) where pools constructed in 2010 are shallower in 2011 and 2012. However, as the pools were constructed below paired deflectors, velocity created by these structures will scour the pools, keeping them clear and it is expected that these pools will retain their current depth profiles into the future.

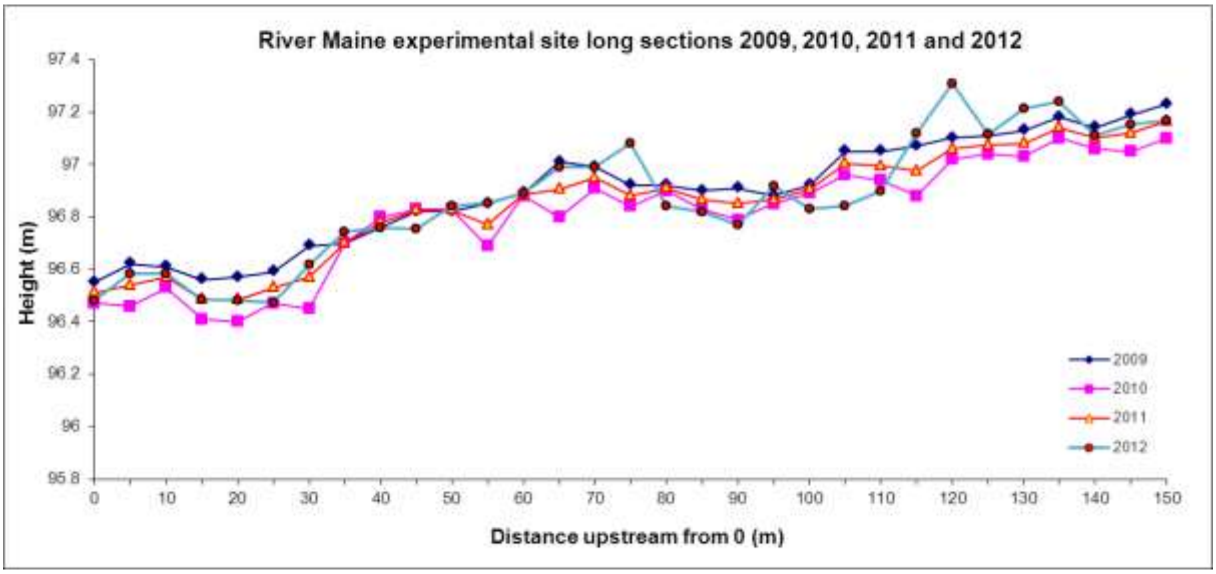


Figure 3.23. River Maine experimental site long sections pre (2009) and post works (2010, 2011 & 2012).

Random boulders and the turbulence and scour they create provide the types of habitat used by both juvenile and adult fish, particularly salmonids. The random boulders placed in the thalweg (Plate 3.5) have 'dug in' into the loose bed material. The boulders increase local velocities to create scour pockets around themselves and in some cases settle into this scour pocket at a new height in the river bed. In this new position they continue to function, developing pockets of deeper water and associated coarse substrate that add to the physical diversity of a river reach. The capital works has increased the average depth from 13cm to 19cm and decreased the average width of the river from 7.9m to 7.3m. Through capital works the river has been narrowed and deepened (Figure 3.24). Post capital works the uniform cross-section, left post drainage, has been altered and is no longer overly wide and shallow. The sequence of riffle / glide / pool seen in natural, undisturbed rivers has been reinstated. Bed material diversity has increased with alternating deflectors and random boulders producing scour that sorts bed material. The increasing habitat diversity put in place through capital works is reflected in the systems increased ability to support juvenile salmonids.

Plate 3.5. Experimental site pre works 2009 (top-left), Post works 2010 (top-right) and 2012 (bottom-centre).

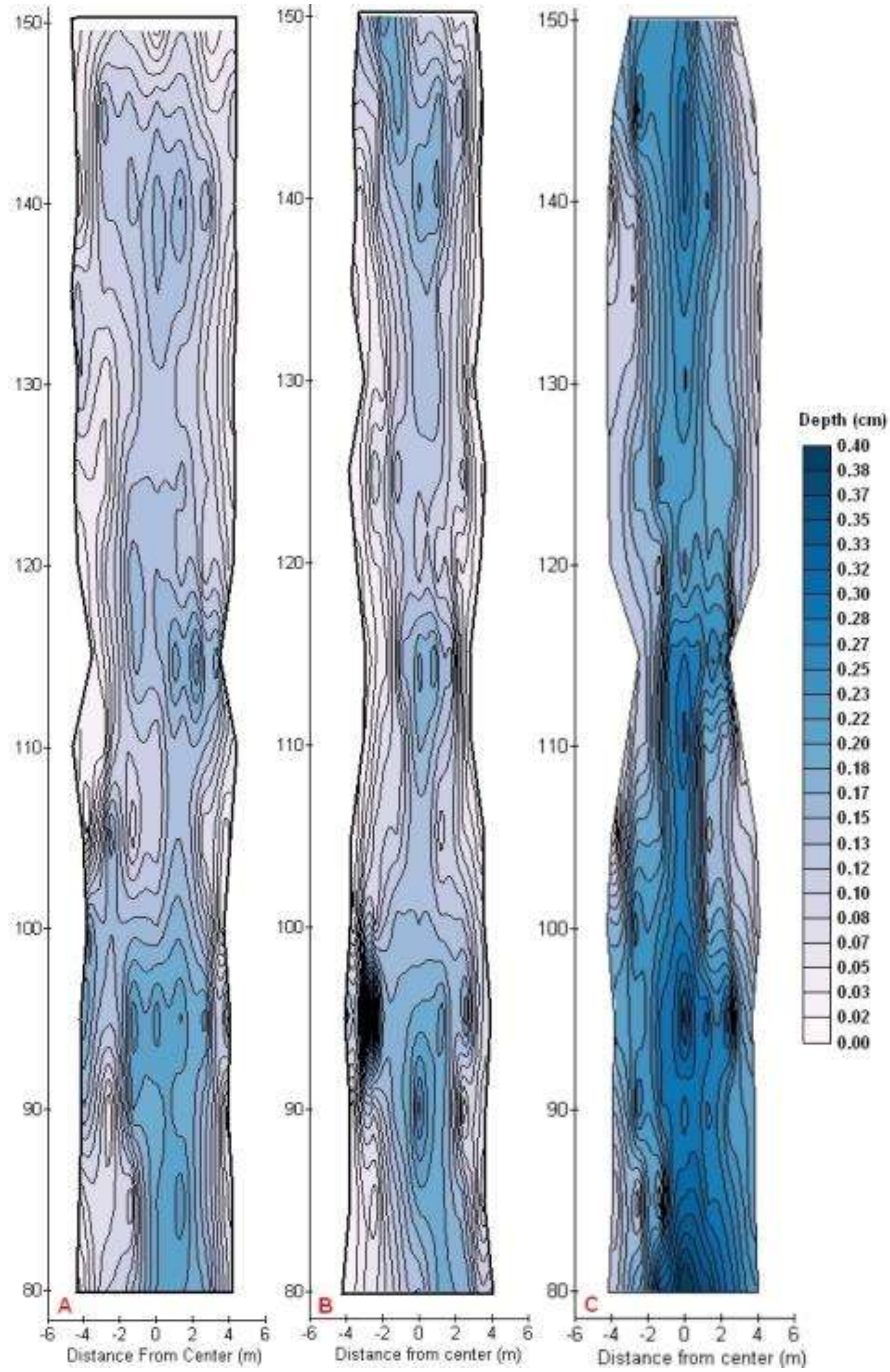


Figure 3.24. A section of the River Maine experimental site depth contours: pre works (2009, (A)) and post works (2011 (B), 2012 (C)).

4 Other Scientific Studies

While crayfish in Ireland are represented by a single species, *A. pallipes*, commonly known as the white-clawed crayfish; lamprey are represented by three species, river lamprey (*Lampetra fluviatilis*) brook lamprey (*Lampetra planeri*), and sea lamprey (*Petromyzon marinus*). As with white-clawed crayfish, all three lamprey species are listed as Annex II species under the EU Habitats Directive. Their inclusion in the directive has legal implications for the OPW maintenance and capital works programmes. As a result it is imperative to monitor the effects of maintenance on both lamprey and crayfish populations in OPW drained channels and to mitigate any potential maintenance impacts.

4.1 Crayfish Studies

OPW-funded studies to examine the impacts of arterial channel maintenance on the white-clawed crayfish have been undertaken by the CFB-IFI since 2006, and have continued in the EREP studies that commenced in 2008 (Figure 4.1). The EREP study covered both channel maintenance practises, and their impacts, as well as capital works projects, where IFI developed proposals to alter the channel form from a relatively uniform one to one with a greater degree of physical diversity and more suited to brown trout and salmon life stages. Monitoring of crayfish was undertaken on the River Robe from 2009 onwards as part of an instream physical habitat enhancement programme under EREP.

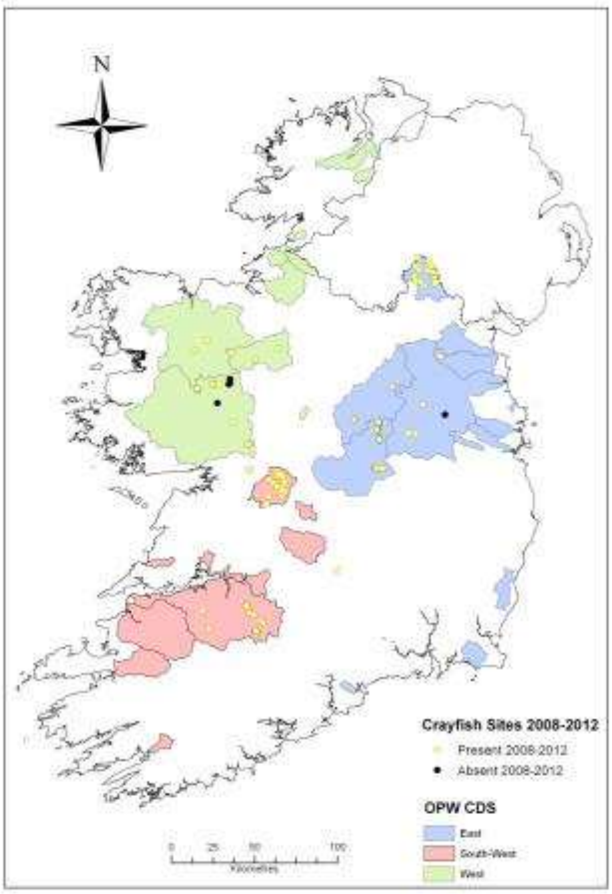


Figure 4.1. Showing the presence/absence of crayfish at sites sampled during the 2008-2012.

The crayfish sampling programme principally examines the crayfish population size and age structure prior to- and in a series of years following maintenance and capital works programmes. This programme is principally carried out using fyke nets which are laid overnight in the channel, and as the predominantly nocturnal crayfish are foraging. Fyke nets, passive sampling devices, were found to be very satisfactory to deploy and were capable of capturing large numbers of samples. The nets consist of two conical ends, with an extended 'leader' net of several metres in length joining the two ends. The ends function as lobster pots, with crayfish working their way along the leader and into the 'pots'. The nets were fished overnight and retained the crayfish alive for sampling, marking as necessary, and for return to the water. A shortcoming of the fyke nets was that the mesh size permitted small or immature crayfish to escape while retaining larger crayfish, in excess of 19 mm carapace length. A major advantage of the fyke nets was that they presented a relatively large target area to intercept the mobile crayfish.

While fyke net sampling remains the main method in which crayfish populations are studied a variety of other techniques have been adopted by the EREP project, such as spoil and vegetation sampling from tarpaulins, hand-grabbing, electrofishing and scat sampling (Figure 4.2). Since 2008 the EREP studies have employed quantitative electrofishing methods, to assess fish stocks in rivers, pre and post capital works and enhanced maintenance surveys. These surveys have also identified sites where crayfish are present, and monitor the effects which these works have on their populations.

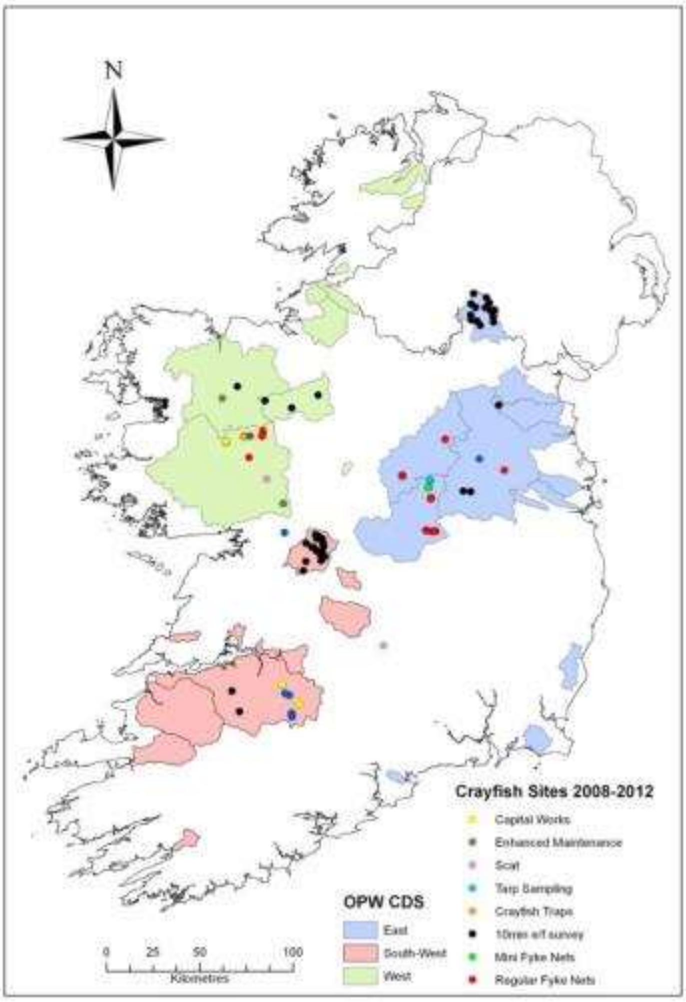


Figure 4.2. Survey methods used in crayfish sampling sites 2008-2012.

Additionally, since its initiation in 2009, the 10 minute Fish Population Index (FPI) electrofishing survey protocol has been used to assess OPW catchments where fisheries information is not available or limited. The FPI focuses on capturing all fish species, as well as crayfish, encountered in surveys. This survey technique has proved invaluable in collection of white-clawed crayfish data at a catchment level. Moreover, the presence of white-clawed crayfish in OPW-channels has also been identified by the presence of crayfish in the scat of otters and mink.

Since 2008 all crayfish data collected by EREP has been fed back to the National Parks and Wildlife Service (NWPS) and contributes to the overall assessments made nationally on white-clawed crayfish populations.

Channel maintenance impacts:

Investigations of maintenance impacts were undertaken in 8 channels, varying in size and also varying in terms of sampling techniques used. The survey procedure, at its simplest, involved collecting a series of samples in an area of channel prior to maintenance, and repeating this sampling at the same locations and same time of year, over a period of years after the maintenance procedure. The underlying assumption was that any changes in population size or structure would be a consequence of the maintenance process and that no other factors impacted.

In studies of both the R. Brosna main channel and the R. Glore (an Inny tributary), the crayfish populations were surveyed prior to maintenance, as usual, and with additional sampling of equal effort undertaken a short period following maintenance. In both cases, the crayfish population did not show any significant decline in numbers in the immediate aftermath of maintenance (Figures 4.3 & 4.4). A follow-up survey on the R. Glore three months after the maintenance event did show a major decline in crayfish numbers (Figure 4.4). The indications are that the maintenance process, in itself, does not lead directly to the major reductions in crayfish numbers. While some crayfish are lost to the channel through removal in spoil and deposition on the river bank, the majority of crayfish survive the actual maintenance process. It is proposed that the decline in crayfish numbers comes about though loss of habitat and feeding for the crayfish and that the animals move away to other locations where shelter and feeding are available.

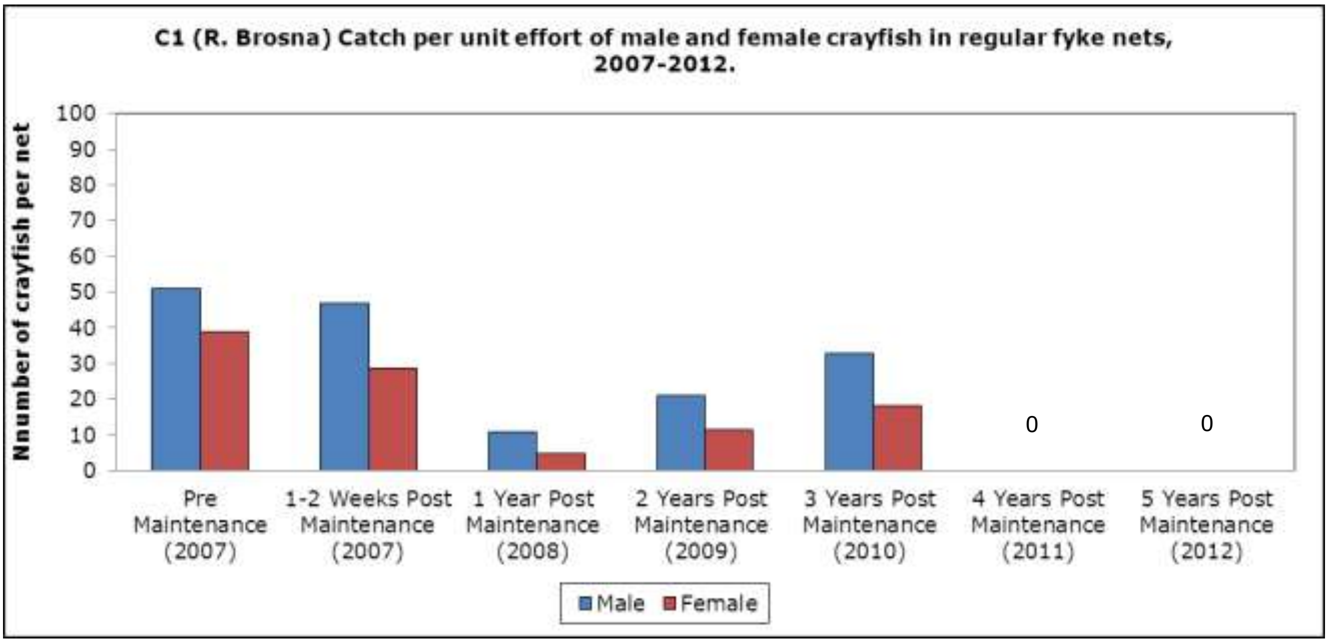


Figure 4.3. Crayfish populations in the R. Brosna, 2007-2012.

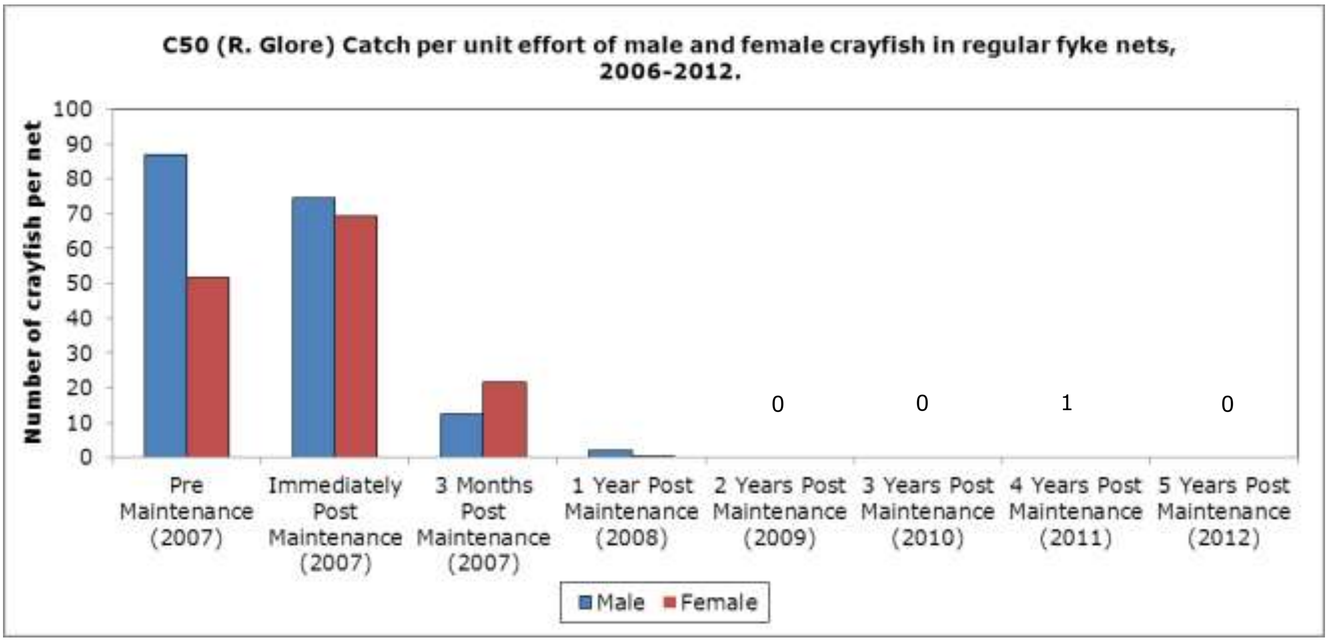


Figure 4.4. Crayfish populations in the R. Glore, 2007–2012.

When the data sets are examined on a year-to-year basis, two patterns of response in crayfish populations were evident. In some cases, the crayfish numbers showed a decline in the year after maintenance and this decline continued for the subsequent years of monitoring. This was the case in the R. Glore (Figure 4.4) and the R. Rath (Figure 4.5). In both cases, crayfish levels declined to zero after a number of years post maintenance and remained absent then over a three-year period. It should be noted though that the R. Glore habitat had shown a recovery following maintenance, with substantial instream and marginal vegetation present thus providing potential cover for crayfish.

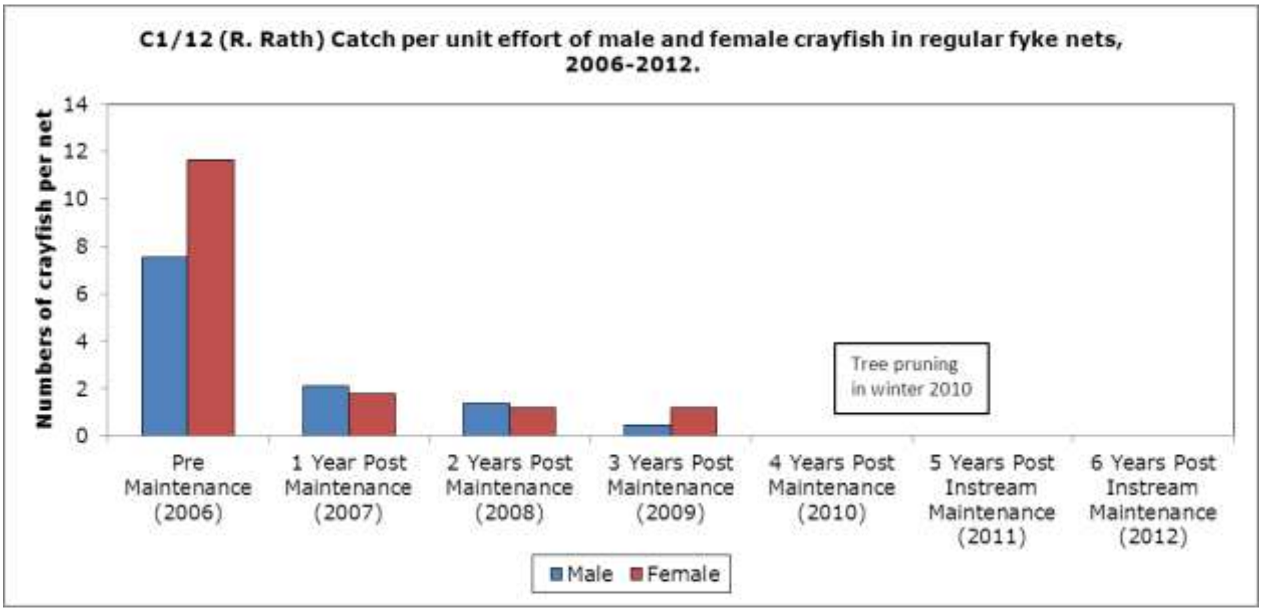


Figure 4.5. Crayfish populations in the R. Rath, 2006–2012.

A different response was observed in the R. Brosna (Figure 4.3) and the R. Tullamore (Figure 4.6) where crayfish numbers showed an initial decline after maintenance but did not immediately fall to zero In both rivers, thereafter, crayfish numbers began to increase in years following maintenance. In the R. Brosna, the population size showed a steady increase in the three years after maintenance before declining to zero levels in the fourth and fifth years. Such a decline cannot be attributed to maintenance and has not been observed in crayfish populations before. The R. Tullamore population showed a substantial increase in 2009, three years after the initial maintenance operation. However, this sampling event occurred immediately after a second round of instream maintenance. The large numbers may be characteristic of a, largely, non-destructive impact of the maintenance - as was recorded on the R. Brosna and R. Glore. The large numbers in the 2009 sampling may have also been due to loss of habitat, displacement of crayfish and a greater ease of capture. The crayfish numbers in the R. Tullamore declined in 2010, the year after the second maintenance event.

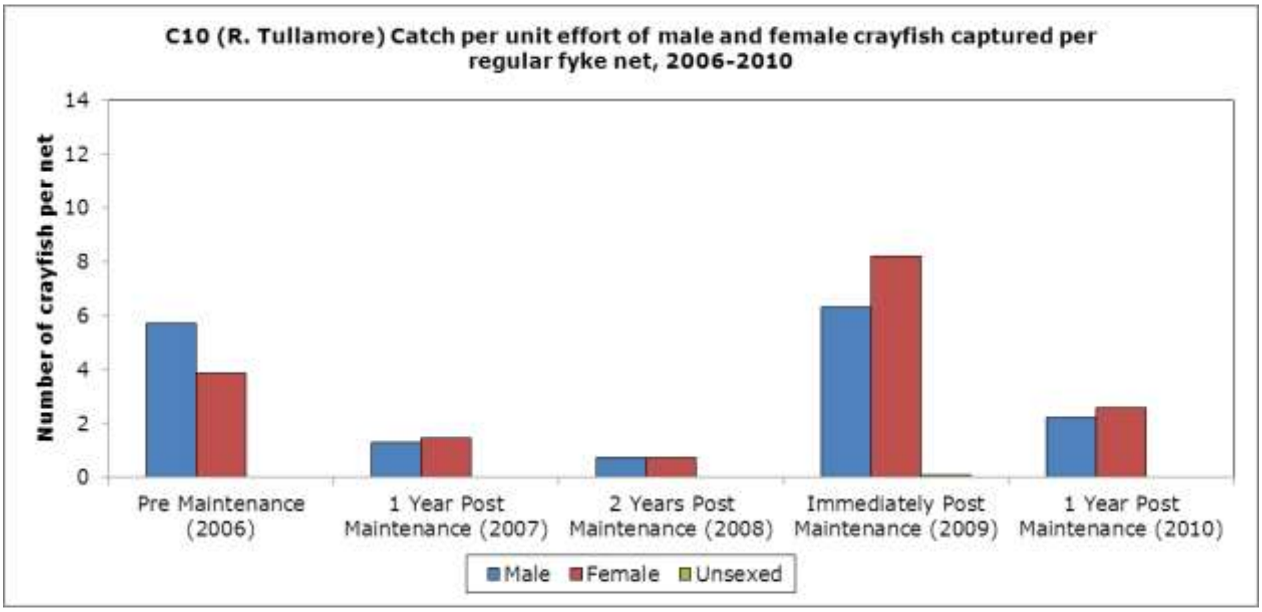


Figure 4.6. Crayfish populations in the R. Tullamore, 2006–2012.

Instream Enhancement - Capital works impacts:

The R. Robe in the Lough Mask catchment has long been noted as a location of substantial crayfish populations. Focussed capital works programmes in the R. Robe, aimed at generating instream diversity of benefit to large brown trout, hence to angling, provided an opportunity to monitor impacts of the works programme on crayfish, as well as on other variables.

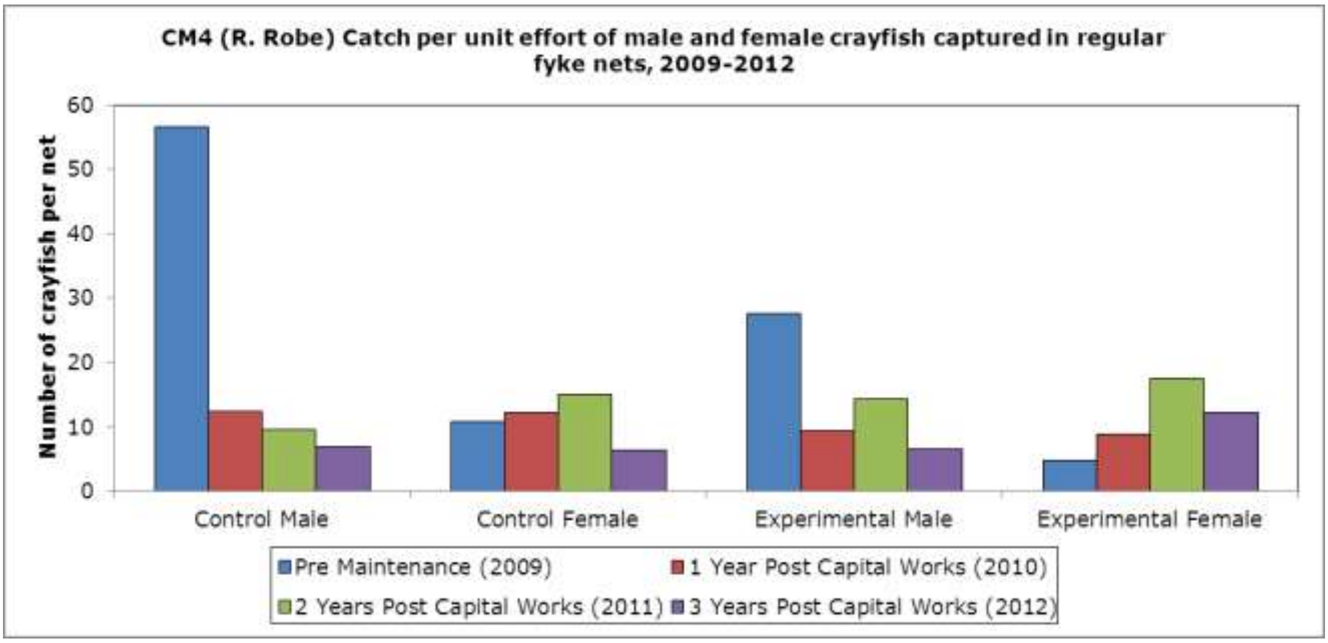


Figure 4.7. Crayfish populations in the R. Robe, 2009–2012.

It is notable that substantially higher numbers of male crayfish, relative to female crayfish, were recorded in 2009 in both the control site and in the works or experimental site prior to works commencing. This difference was not detected in subsequent years (Figure 4.7).

There was a statistically significant difference in population levels between the control and experimental sites (male and female crayfish combined) prior to any works in 2009 (Mann-Whitney U test, $P = <0.05$). No significant differences in numbers between control and experimental were detected in any of the three years of monitoring following the instream works. When the control site, alone, was examined statistically there was a significant difference between the 2009 pre works population level and the post works levels in each of the following three years (Mann-Whitney U test, $P = <0.05$). There were no significant differences between population levels in the control site in the three years following the instream works. No statistical differences were recorded (Mann-Whitney U test, $P = >0.05$) between years for the experimental site, covering the pre and post works period.

It is preferable in experimental design to locate a control site upstream of an experimental. In the present case this was not an option as sites of comparable physical habitat - instream and riparian - were not available upstream of the selected experimental site. The reduction in population was most notable in the control site.

The instream excavations and boulder placement operations were substantial and were considered likely to have a disruptive effect on crayfish populations - as was the case for maintenance operations reported above. However, no statistically significant changes were recorded in the experimental site in the annual monitoring programme although short-term changes might have occurred during and in the immediate post works period. The only decline in numbers recorded was in the control site, where post works population levels were the same as those recorded in the experimental site.

The works programme was focussed on creating diversity of brown trout habitat in an otherwise relatively deep and uniform adult trout habitat. The works process did not impact in a manner that led to collapse of the crayfish population. The stability of the crayfish populations in the experimental site, compared to outcomes from the channel maintenance studies reported above, may point to the stone structures installed as creating a suite of habitat niches and hiding places that the crayfish present, displaced by the works disturbance, were able to colonise immediately. Further rounds of monitoring will continue to assess crayfish status and may indicate further trends. It has been noted, in respect of fish species, that instream works of the form undertaken here may take a number of years for full impact and benefit to work through to fish populations. This may also be the case here for crayfish.

4.1.1 Fyke Netting Data Analysis

Since 2006 a number of experimental fyke netting surveys have been undertaken to examine the effects OPW drainage maintenance has on crayfish populations. Survey sites were broadly dispersed among OPW catchments, on limestone geology (Figure 4.8). For each site, pre maintenance surveys were carried out to determine the initial population size and structure. The surveys where then replicated on a yearly basis, in the same season, to examine the effects of maintenance on the crayfish populations.

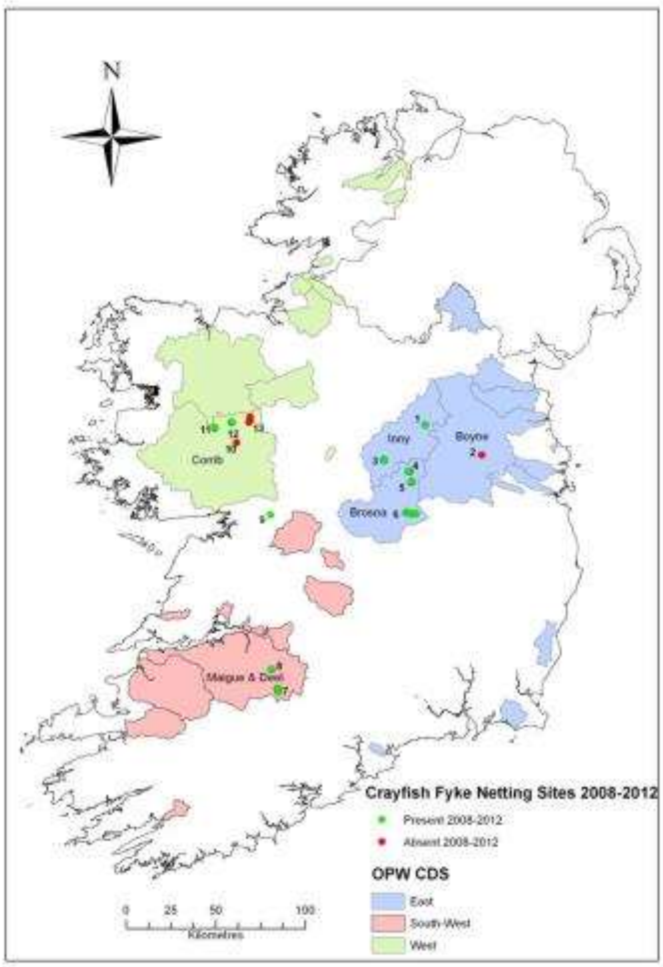


Figure 4.8. Crayfish fyke netting sampling sites 2008-2012.

Post maintenance one would expect that crayfish populations would decrease due to a number of direct and indirect factors, such as mortality from the bucket and/or loss of habitat. Direct mortality from maintenance is considered relatively low, and that the major contributing factor causing decreases in crayfish population densities are loss of habitat and/or food (King *et al*., 2008). Analyses of the catch per unit effort (CPUE) results indicated that this was the case, as there were significant differences in the median CPUE pre and post channel maintenance using both the mini and regular fyke nets (Kruskal-Wallis test, P = <.0.5) (Table 4.1). Pairwise comparison tests indicated significant differences between the pre and the post works results for both the mini (Mann-Whitney U test, P = <0.05) and the regular (Mann-Whitney U test, P = <0.05) fyke nets.

Table 4.1. Fluctuations in the crayfish numbers pre and post maintenance works in mini and regular fyke nets.

Year	**Crayfish CPUE Values**	
	Mini	**Regular**
Pre Maintenance	6.92	21.01
Post Maintenance	4.36	4.04

If a viable population remains in the channel post maintenance, and if conditions in the channel are suitable, it is projected that crayfish densities would increase gradually over time and recover to pre maintenance levels. However, if the channel is maintained prior to the population recovering to pre maintenance levels, the population may be detrimentally harmed leading to a significant reduction in the numbers of crayfish present in the channel over time. With this in mind, the crayfish CPUE values for each year post works were examined and compared to pre maintenance results.

A Kruskal Wallis test was carried out on the CPUE values across five of the seven maintenance categories (note that both the 5 years and 6 years post maintenance results were unable to be tested statistically, as zero crayfish were captured in the nets concerned) (Table 4.2). This indicated a significant difference in medians between the treatments ($P = <0.05$) In order to determine where this significance lay, Mann-Whitney U tests were performed, for both mini and regular fyke nets, comparing the pre maintenance CPUE values to each year post.

Table 4.2. Fluctuations in the crayfish numbers pre and post maintenance works in mini and regular fyke nets.

Year	**Crayfish CPUE Values**	
	Mini	**Regular**
Pre Maintenance	6.92	21.01
1 Year Post Maintenance	3.83	1.49
2 Years Post Maintenance	1.83	6.49
3 Years Post Maintenance	10.73	15.26
4 Years Post Maintenance	2.87	0.03
5 Years Post Maintenance	n/a	0
6 Years Post Maintenance	n/a	0

Analysis of the results indicates a trend whereby the CPUE values, which had decreased significantly from pre maintenance levels in both the mini (Mann Whitney U test, $P = <0.05$) and regular fyke nets (Mann Whitney U test, $P = <0.05$), gradually increased from 1 year post through to 3 years post maintenance, thus indicating a recovery of the crayfish population within the channels concerned (Table 4.2). The recovery was to such an extent, that by 3 years post maintenance there were no significant differences in the CPUE values when Mann Whitney U pairwise comparisons were made with the pre maintenance values in both the regular (P = >0.05) and mini (P = >0.05) fyke nets. This indicates that the population had recovered to pre maintenance density levels.

However, as seen from table 4.2, there was a significant drop in crayfish numbers in years 4, 5 and 6. It is worth mentioning here that, while these fyke net surveys examine the impact that OPW drainage maintenance has on crayfish populations, it does not take into account additional anthropogenic and non-anthropogenic factors which may cause variations in the CPUE Such factors include increases in predator numbers (trout, pike, perch and eels), presence of the crayfish plague, water temperature and weather condition fluctuations.

For instance, while there was a significant decrease (Mann Whitney U test, P = <0.05) in crayfish numbers 1 year post maintenance in the Brosna channel, by 3 years post, there was no significant difference between the pre and post maintenance median CPUE values (Mann Whitney U test, P = >0.05). This indicated that the channel had recovered to pre maintenance levels. However, in year 4 and year 5, zero crayfish were captured in the channel. The reason for this population collapse is yet unknown, but could be attributed to a variety of factors such as the crayfish plague and/or increase predation levels.

4.1.2 Mitigation Measures

OPW drainage maintenance can have significant impacts on crayfish population densities but these effects are not irreversible. From the results it is clear that if a viable population remains in the channel post maintenance, given sufficient time and a suitable habitat, crayfish population densities have the capacity to recover to pre maintenance levels. From the results it is clear that if a viable population remains in the channel post maintenance, given sufficient time and a suitable habitat, crayfish population densities have the capacity to recover to pre maintenance levels. Close adherence to OPW's own Standard Operating Procedures (SOP) and their '10 Steps to Environmental Drainage Maintenance' is vital in the conservation of crayfish populations (OPW, 2011).

In order to protect crayfish populations during and post channel maintenance, it is the recommendation of this report that the following mitigation measures be adopted and/or enforced by the OPW.

- Prior to the implementation of any maintenance works, the presence of crayfish in the channel firstly needs to be identified. This can be done by checking OPW and IFI records to determine if crayfish have ever been recorded in the channel. This can also be completed on site by the OPW driver and/or foreman during initial maintenance works. Once identified it is vital that their presence be recorded on the daily OPW record card for future records, as it should have future consequences for channel maintenance.

- If crayfish are present, the frequency at which the channel is maintained should automatically be examined. As seen from EREP surveys, crayfish populations can return to pre maintenance levels approximately 3 years post maintenance. Therefore it is recommended that if crayfish presence is verified, the channel should automatically move to a longer maintenance cycle. For instance, increasing the cycle from 3 years to 5 years. It is also suggested that no channel with crayfish present be maintained on less than a 4 year cycle. This should provide sufficient time for population densities to return to pre maintenance levels, assuming no other changes have occurred. This should ensure a vital population has been established in the channel prior to the next maintenance works.

- As a major contributing factor causing decreases in crayfish population densities during OPW maintenance is the loss of habitat and/or food, a vital mitigation measure is to leave sections of instream vegetation and/or the channel untouched. This component of the '10 Step' plan helps to ensure the availability of suitable habitats and food for the remaining crayfish population.

- As the omnivorous crayfish rely on instream vegetation both as a food source and a refuge, the removal of this vegetation during maintenance may have significant impacts on populations. The use of weed cutting buckets and/or boats may prove ideal in channels where a compromise is required between the retention of instream vegetation and the alleviation of potential flood risks. The use of the weed cutting bucket allows vegetation to be completely removed from the channel without impacting the sediment. Alternatively the weed cutting boat allows the improvement of water conveyance by the removal of instream vegetation, while at the same time retaining the basal root habitat and food source for crayfish.

- If crayfish are present, the spoil heaps need to be thoroughly examined, and all crayfish removed by the bucket be returned to the channel.

- As female crayfish are 'In-berry' with until late June or July, that is they carry their eggs on their abdominal appendages, it is recommended that in channels where crayfish are known to be present, maintenance works not be undertaken until July at the earliest.

- If crayfish are present in a channel, allow the water from the bucket to return to the channel prior to placing it on the spoil heap. This will allow crayfish, and other species to return to the channel.

While the above are the recommendations for all OPW drained channels, each site should be addressed separately and different mitigation measures may need to be adopted on a site specific basis.

4.2 Lamprey Studies

Since 2008 comprehensive surveys have been undertaken on a large number of capital works and enhanced maintenance sites, to access juvenile lamprey stocks in rivers (Figure 4.9).

These surveys not only provide data such as presence/absence and length frequency distributions for lamprey populations, they also monitor the effects which these works have on their populations. Additionally, since 2009 the EREP studies have employed the 10 minute Fish Population Index (FPI) electrofishing survey protocol to collect lamprey data at a catchment wide level. For instance, in 2012 the Monaghan Blackwater FPI indicated 3 channels in which river/brook lamprey were present, for which no data had previously been recorded.

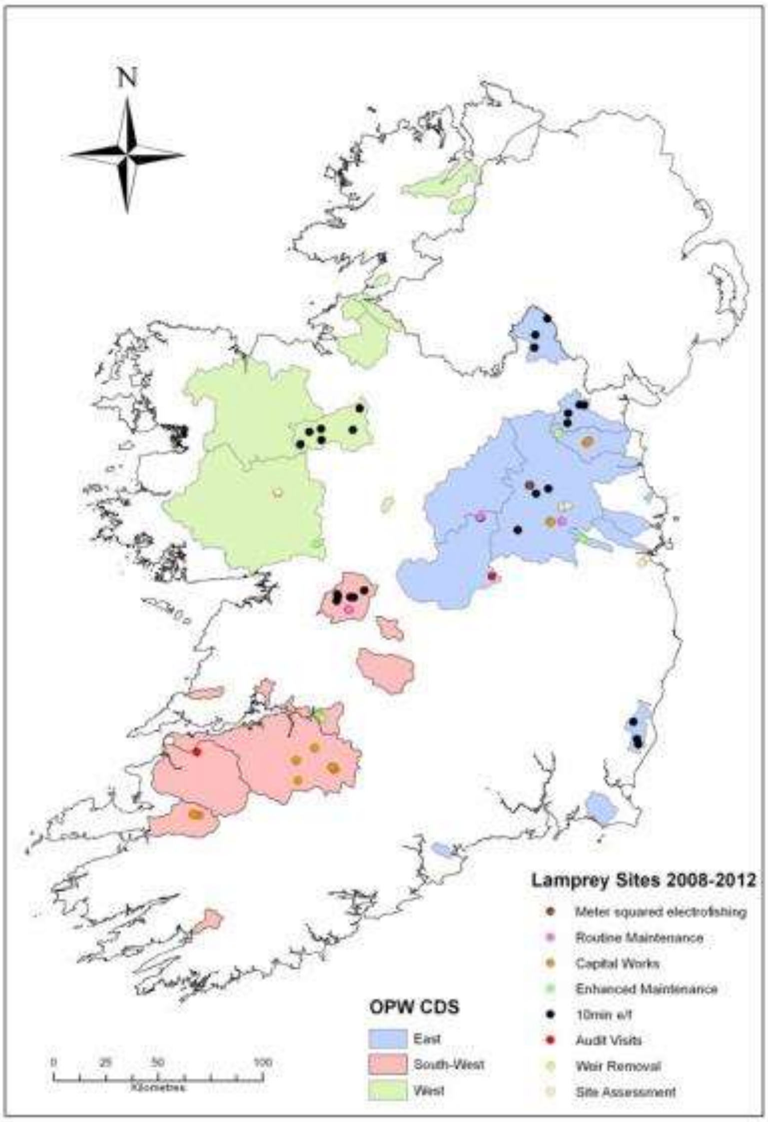


Figure 4.9. Survey methods used in lamprey sampling sites 2008-2012.

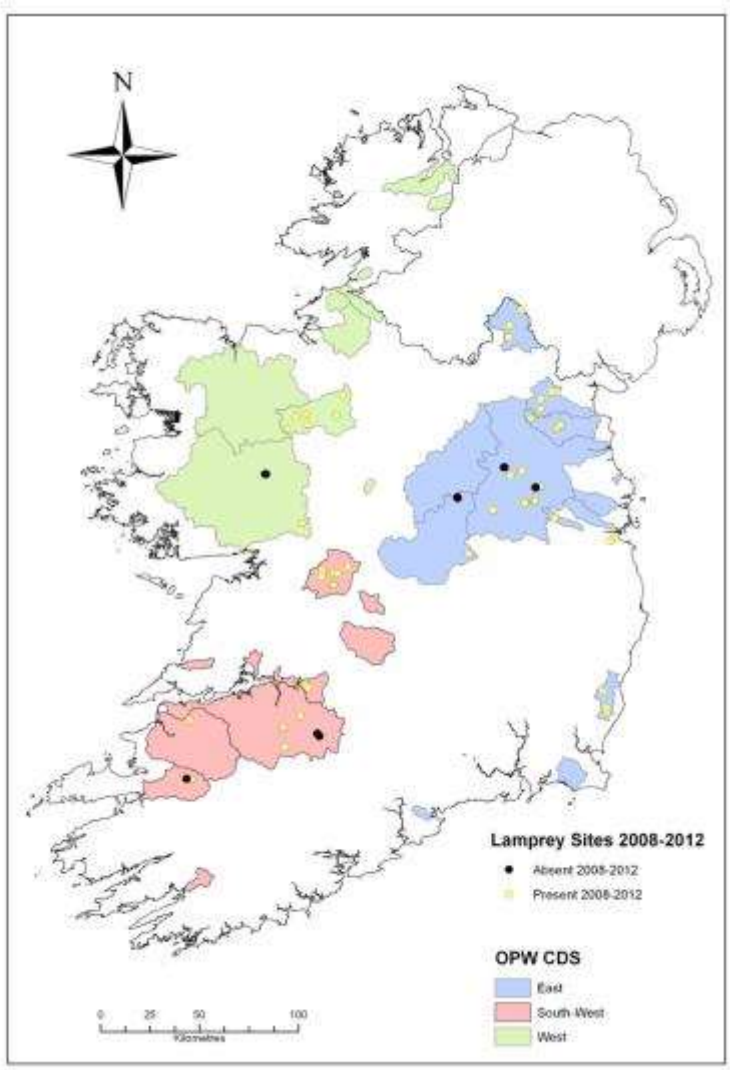


Figure 4.10. Presence/absence of lamprey at sites sampled during the 2008-2012

While electrofishing remains the main methods by which the EREP project study lamprey populations, a variety of other techniques have also been utilized. For instance, to determine the presence/absence of lamprey in an area of channel, sweep net sampling and qualitative spoil and/or vegetation sampling have also been undertaken. These type of survey can give invaluable insights into the potential impacts OPW works can have on a channel, and also which substrate type lamprey utilize.

4.2.1 Monitoring studies on the River Stonyford

Long-term impact study: the Stonyford River-C1/32 Boyne 2007 - 2012

In the R. Stonyford, 18 enclosures, each of one metre square, were set up along a 500 metre section of channel that was identified as containing optimal ammocoete habitat and these enclosures were quantitatively fished prior to maintenance in May 2007. Approximately seven weeks later, post maintenance electrofishing were carried out in the same pre maintenance enclosure sites. The OPW machine drivers had been specifically requested to focus on silted areas of the channel and not to implement their environmental protocols in regard to retaining marginal habitats. Monitoring of recovery was continued annually, at same time of year, over a five-year period up to 2012. In view of local annual variation in location of bed materials and aquatic vegetation, sampling took place in areas of fine sediment deposition at or as proximal to the original pre maintenance sampling enclosure site as was feasible.

An overview of trends in juvenile lamprey density indicated a substantial decline after maintenance works followed by a recovery in levels after some years. Mean density declined in the immediate post maintenance period and remained low over the following two years. From the third year after works and onward, mean density increased to a level comparable with the pre-works density (Figure 4.11).

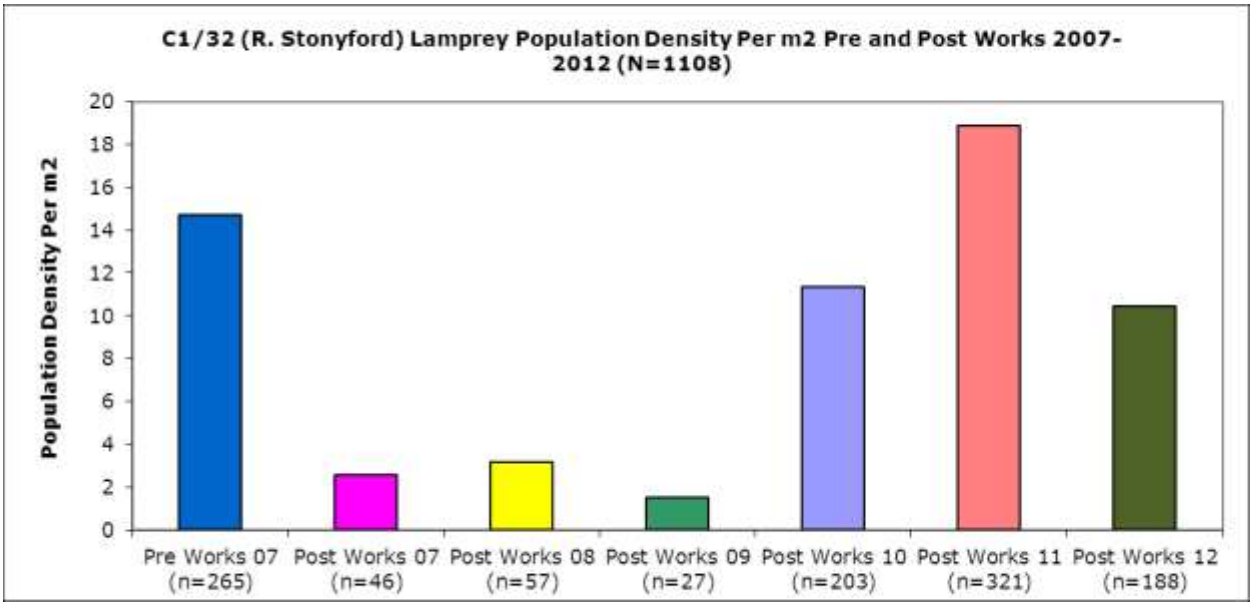


Figure 4.11. C1/32 (R. Stonyford) Comparison of the lamprey population density per m^2, pre and post maintenance works, 2007-2012.

The population structure of the juvenile lamprey prior to maintenance in 2007 showed the presence of a number of year classes or ages, based on modal peaks. No modal groups were particularly prominent (Figure 4.12). Of significance was the number of larger ammocoetes present in the 120 - 130 mm range. The population structure in the immediate post maintenance sampling showed that a wide range of size classes continued to occur in the study sites. Statistical comparison of population structures indicated a marginally significant difference (G test (with Williams correction), G = 14.2, df=7, P = 0.048).

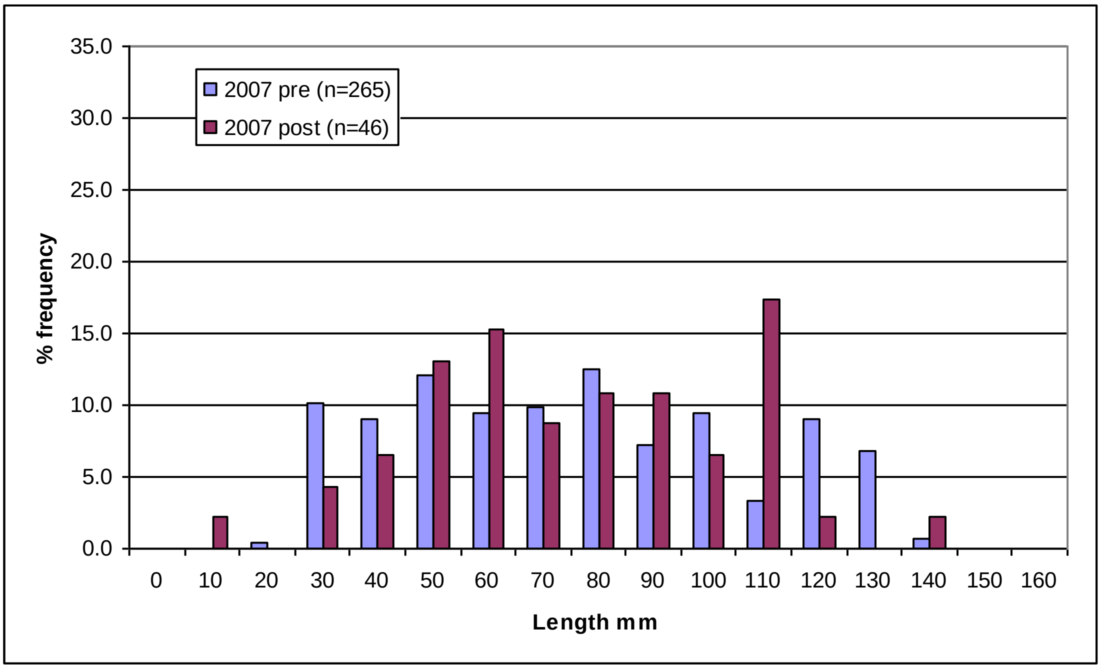


Figure 4.12. Percentage length frequency of ammocoetes before and after maintenance, 2007.

In 2008, one full year after maintenance, a wide range of lengths was recorded among the juvenile lamprey with a prominent modal peak of younger animals of 30 mm (Figure 4.13). This suggested recruitment from spawning activity that had occurred in adjacent upstream areas in 2008, with subsequent drift downriver and colonisation of available sediments. There was a reduction in the number of larger sized ammocoetes, even relative to the post maintenance data of 2007. This may indicate that, while larger sized ammocoetes were present in the short-term following maintenance, the alterations to habitat and sediment availability created by maintenance led to displacement of these larger animals with colonisation of whatever sedimenting habitat was available by younger, smaller lamprey recruiting into the habitat.

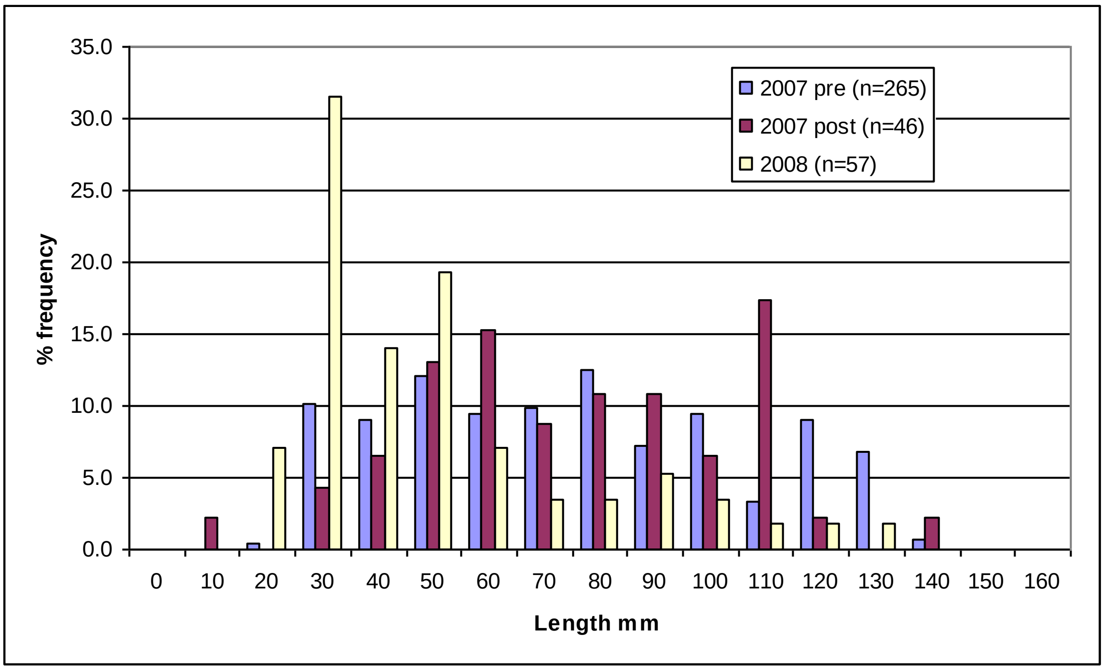


Figure 4.13. Percentage length frequency of ammocoetes before and after maintenance, 2007 - 2008.

Heavy growths of water celery vegetation occurred in the channel in 2009 and this contributed to an increase in water depth. The root mass of this vegetation grew profusely in what would have been suitable fine-sediment habitat for juvenile lamprey and this may have prevented or hindered colonisation by juvenile lamprey - leading to the low numbers recorded. The habitat was largely clear of this nuisance plant from 2010 to 2012. Areas of sediment deposition were clearly evident in these years, rendering electrofishing feasible for juvenile lamprey sampling.

Over the period 2010 - 12, from 3 to 5 years after maintenance, the population structure continued to develop from that of 2008, with a shift to populations dominated by ammocoetes in the size range 30 - 80 mm. Given the peak of young ammocoetes in 2008, it might have been anticipated that this group would have dominated the population structure and its modal peak would have progressed through the population over a period of 4 - 5 years and would have populated the 120 - 130 mm size component. Such a progression was not apparent. However, it is clear that recruitment of fish in the 30 mm size range occurred in 2010 and 2011 (Figure 4.14), indicating on-going successful spawning. These recruitment events led to successive waves of younger fish contributing to the length frequency range in successive years. Statistical comparison (G test) of the population structures indicated that the pre-maintenance data set differed significantly from post-maintenance data in all years. A major feature of the pre impact population structure was the presence of a substantial number of larger ammocoetes (120 - 130 mm). This size group was either absent or poorly represented in the post-impact years of study.

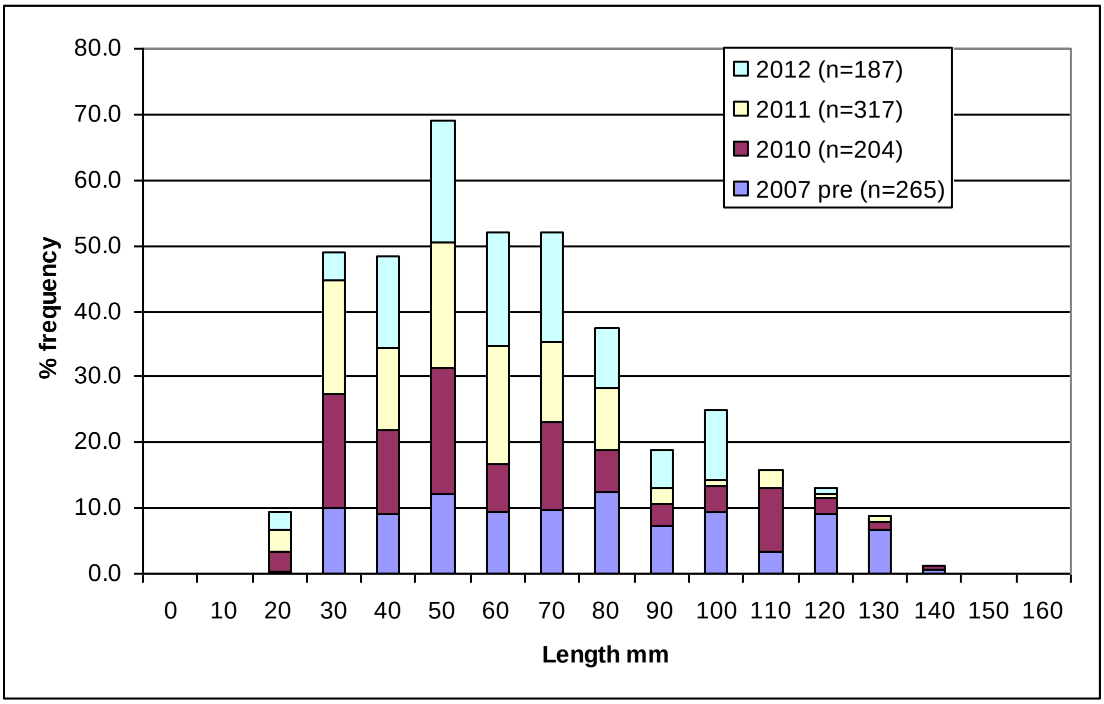


Figure 4.14. Comparison of percentage length frequency of ammocoetes before maintenance (2007) and in the post-maintenance period (2010 - 2012).

Measures of central tendency were examined to tease out further apparent changes in population structure over the study period (Figure 4.15). The length frequency distributions indicated a multimodal structure in most years, pointing to a non-normal distribution. Thus, use of the mean and its associated standard error may not be strictly accurate in this case. However, the calculated mean values did indicate a decrease in size in the first year after impact and a subsequent trend of increasing value - without reaching the mean values of the pre- and immediately post- impact populations. This reflects the absence of the substantial cohort of larger ammocoetes from 2008 onwards. The median values, the value having 50% of observations smaller and 50% larger, followed the trend of the mean values while the mode, that datum most commonly occurring, declined immediately after maintenance and has its lowest value in 2008. Modal values increased in subsequent years with the 2012 value (55 mm) being almost identical to the pre-maintenance value (57).

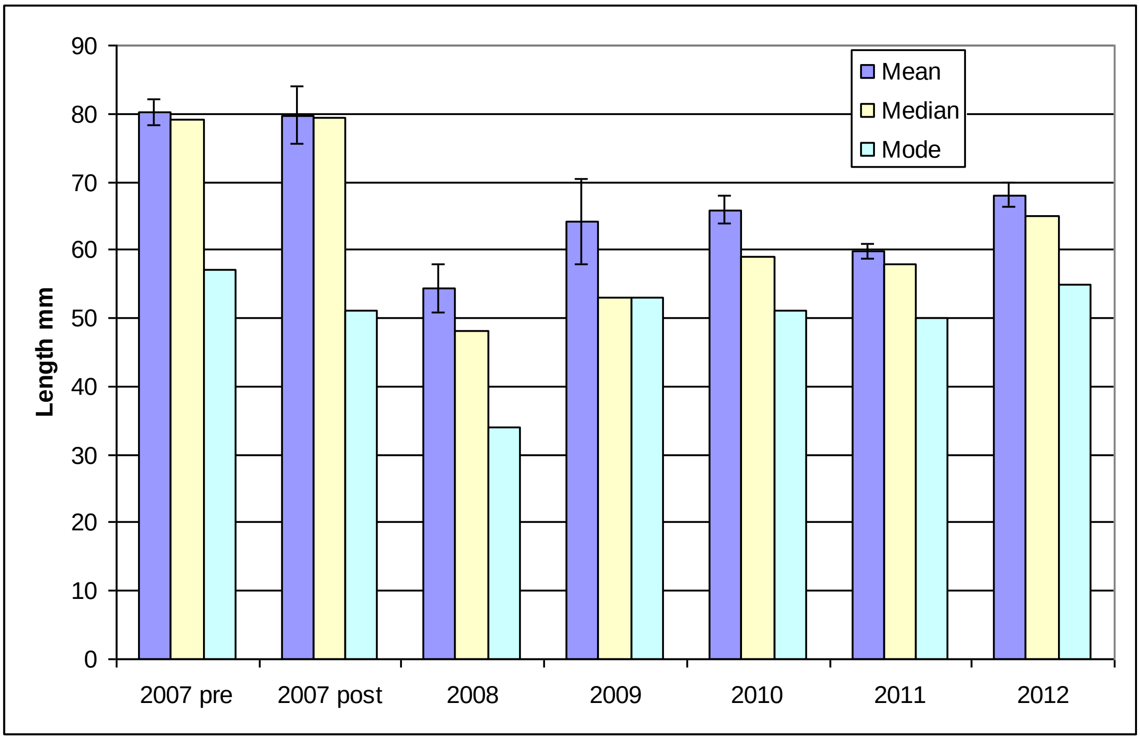


Figure 4.15. Comparison of ammocoete length (mm) using measures of central tendency before maintenance (2007) and in the post-maintenance period (2008 - 2012).

An overview would indicate that maintenance has the potential to have a drastic adverse impact on lamprey ammocoetes populations. It is also apparent that recovery can occur in a channel, where resident populations or spawning effort are available from upstream to colonise the impacted site. This recovery was clearly evident in the third year after the maintenance impact. The continuing limited representation of larger sizes of ammocoetes, relative to the pre-maintenance situation may point to some habitat element having been lost in maintenance and not recovering.

Channel maintenance and lamprey habitat - on-going issues into the future

IFI and its predecessor emphasise the status of lamprey - juveniles and adults - as Annex II Habitats Directive species. The issue of juvenile lamprey and their residence in areas of fine sediment is particularly problematic to OPW, as sediment deposition and associated vegetation growth are factors that can lead to perceived channel impedance and trigger a channel maintenance event. The EDM studies addressed issues related to lamprey in OPW channels and brought forward an ecological impact assessment dealing with this issue (King, Hanna and Wightman, 2008). This document also brought forward a series of both short- and long term mitigations that could be implemented by OPW. In addition, the EDM guidance notes on environmental strategies emphasised the importance of retaining habitats along the channel margins during maintenance. This included areas of vegetation growth and areas of bare sediment. Sediment deposition is most likely to occur along the channel margins. Another important issue identified in the ecological impact assessment was the potential for certain types of vegetation, often growing in open water, to trap sediment of a type that could be colonised by juvenile lamprey. The ‘flagger’ or *Sparganium erectum* is particularly notable in this regard and foremen are now constantly advised that, when drivers are encountering large stands of flaggers in open water, particular attention must be paid to presence of juvenile lamprey and the standard operating procedure (SOP) implemented.

It is problematic for OPW to retain stands of tall emergent plants, such as flaggers, in the open channel as this almost serves to undo the purpose of the maintenance operation. However, it is possible to retain a significant element of flagger growth where this occurs close to the bank and grows outward from the bank. Management of flaggers in such cases can lead to a reduction in size of the plant stand in the open water areas and retention of growth closer to the bank. This provides a mitigation for resident juveniles - retaining both habitat and individuals. Juvenile lamprey displaced by the removal of open water flaggers and washed downstream may find some of the marginal flagger habitat retained and take up residency. This strategy of retaining significant marginal stands of flaggers was implemented with success by OPW drivers in two Enhanced Maintenance operations in 2012.

Despite best efforts of all it is inevitable that, if maintenance is underway in a channel with juvenile lamprey populations, there will be loss of juveniles to the spoil taken from the channel. Drivers are required to examine spoil for evidence of crayfish and lamprey three times a day, as per SOP.
It is evident to IFI personnel in this project that machine drivers need more training and auditing to increase their awareness of the occurrence of lamprey and crayfish in the spoil. One state body has developed a SOP in relation to juvenile lamprey where the maintenance excavator crew examine the spoil and remove juvenile lamprey (or crayfish) to buckets of clean water for subsequent placement back into the channel downstream of works. From direct experience, this approach can save a considerable number of juvenile lamprey.

Revised legislation transposing and enabling implementation of the Birds and the Habitats Directives of the EU into Irish law was enacted in 2011 (S.I. 477 of 2011). As previously, this obliges the Minister charged with fisheries to oversee the conservation of Annex-listed fish species - the Atlantic salmon, lamprey species, shad species and pollan (*Coregonus autumnalis*). Of major concern to OPW are the salmon and lampreys. IFI is implementing this conservation and surveillance charge on behalf of the Minister of the Committee on Environment and Natural Resources (CENR) and must look to all impactors on lamprey status and on working with interested parties to develop and upgrade mitigation measures.

Visits to works sites have identified the increasing extent of one-person operations at OPW machines. This is arising from retirement and non-replacement due to government embargos on recruitment. This development renders more difficult any strategy of increased mitigation by driver crews

Data Analysis

According to the Kruskal-Wallis test there is a significant difference (P = <0.05) between the median densities/m2 pre and post channel maintenance.

Pairwise comparison tests indicated significant differences between the pre works density/m2 data and the post works results for 1 year post (Mann-Whitney U test, P = <0.05) and 2 years post maintenance works (Mann-Whitney U test, P = <0.05). However no significant differences were found between the lamprey densities/m2 pre works data and the 3 (P = >0.05), 4 (P = >0.05) and 5 (P = >0.05) years post works data (again using Mann Witney U test). This would suggest that drainage maintenance is negatively impacting on lamprey numbers in the immediate aftermath of maintenance and this continues into the second year post maintenance. There appears to be some recovery in the lamprey population by year 3 post maintenance (Figure 4.11).

5 Scientific Monitoring Over-view

A brief general summary of all EREP biodiversity monitoring is provided in this section. It presents the general trends observed throughout the full EREP project.

5.1 Monitoring

5.1.1 Fish Monitoring

Pre and Post Monitoring Sites

- Majority of sites showed increases in fish densities within 1 year post works.
- Increases in fish numbers are not always noted amongst all life stages of salmonids and for trout and salmon.
- Long term monitoring data not yet available, but other studies indicate that the significant increases seen within the 1st year are not always maintained in subsequent years.
- Difficulties with some monitoring sites

  -Some OPW work programmes not carried out so only have pre works data.
  -Weather.
  -Changes in status to channel – such as water quality and management of banks by landowner.

All FPI electrofishing surveys

Benefits - Provide a mini baseline survey of that catchment.
Provide fish information that feeds into the WFD fish database.
May be only source of data that will determine ecological status of that waterbody.

5.1.2 Flora Studies

- Instream vegetation – no major loss of species diversity if small sections left intact – recovery within a few years.
- Fencing can have the most significant positive impact in terms of riparian and marginal vegetation cover.
- Most potential for damage is in areas of drains, back waters and low gradient channels through fens and bogs.
- Extensive rip-rap can be very damaging and prevents good regrowth.
- Reducing excessive tunnelling can increase diversity.

5.1.3 Bird Studies

- No significant difference between drained and undrained survey sites.
- Diversity and abundance is very reliant on vegetation cover – trees and marginal vegetation very important.

- Issues with monitoring - many sites only had pre works as maintenance not carried out on selected sites afterwards.
- Not going forward into new EREP programme.

5.1.4 Macro-invertebrate Monitoring

- Macro-invertebrates greatly affected by vegetation cover, substrate material, water quality and flow rate.
- Most significant changes are noted when tunnelled areas opened up and when you get greater bed material diversity.
- Some difficulties with monitoring sites – continued works upstream of monitoring sites influenced some of our control sites.
- Not going to continue monitoring macro-invertebrates in EREP 2 except in cases where rubble mats are in the design plan.

5.1.5 Physical Monitoring

- Implementing physical changes to the river is what EREP is really all about.
- EREP provides the opportunity to improve the hydromorphology of a river post drainage.
- The response of the river to physical channel changes can be observed through a range of biodiversity elements such as fish, plants, birds, lamprey etc.
- Need long tern dataset to determine life span of some aspects of physical changes and structures.

5.1.6 Lamprey Monitoring

- Difficulty in identifying sites to study within OPW Maintenance Programme.
- Long-term monitoring data indicates:
  - Significant disturbance post maintenance.
  - Recovery of population structure and density can occur after 3 – 4 years.
  - Lot of mixed results to-date.
- Substantial loss of juvenile lamprey to spoil can occur in maintenance
- Heavy growths of flaggers (bur reed) can trap silt that is ideally suited to juvenile lamprey and particular care must be exercised in these areas
- Likely to use undrained catchments as controls going forward.
- Highlights the need for OPW to fully implement all aspects of its own environmental protocols for lamprey in all channels.

5.1.7 Crayfish Monitoring

- Long-term monitoring data indicates two responses to maintenance:
  - Significant disturbance post maintenance with a recovery over 3 – 4 years.
  - Significant disturbance to zero levels with no recovery evident after 3- 4 years

- A lot of mixed results to date with other not recently maintained sites showing unexplained zero levels.
- The zero levels are at variance with the fact that the same channels have had multiple less environmentally sensitive maintenance over previous decades but still had crayfish populations at the start of monitoring.
- Heavy instream growths of flaggers and/or bulrush can house substantial populations of crayfish
- Highlights the need for OPW to fully implement all aspects of its own environmental protocols for crayfish in all channels.

5.2 Future Monitoring Programme 2013 – 2017

The current 5 year EREP project has been completed. A second phase is to commence immediately continuing on directly from the original EREP project. The second phase of EREP will run from 2013 to 2017. While in general this new EREP project will have the same aims and objectives as the previous one a number of changes will be implemented throughout the course of the new project which will allow the project to more successfully achieve its deliverables.

The project will be more targeted and focused in its approach to enhanced maintenance and its capital works programme. To accommodate these changes certain elements from the original EREP project will have to be reviewed and altered to facilitate the necessary changes going forward. The most significant of these changes will be in the EREP monitoring and bio-diversity aspect of the project. The same level of commitment, in terms of time and resources, is not possible if there is to be a greater emphasis on identifying, walking and designing both enhanced maintenance and capital works programmes.

The new scientific monitoring programme will require the following changes:

- No bird surveys.
- Reduced fish monitoring programme.
- Reduced plant surveys.
- Reduced physical surveys.
- Almost no macro-invertebrate studies.
- One more brown trout genetic study (Moy catchment).
- Modified lamprey and crayfish studies:
    - Monitoring of lamprey and crayfish sites where OPW have fully implemented their own environmental protocols.
    - Include control sites in non OPW catchments in relation to lamprey and crayfish.

Even with such changes to the existing monitoring programme it is felt that EREP can still deliver valuable information in relation to the impacts of drainage maintenance on the channel hydromorphology and the bio-diversity of the whole river corridor and the improvements and benefits that capital works programmes will have on many aspects of the river, from fish to hydromorphology.

6 Brown Trout Genetic Studies

6.1 Introduction

One of the main challenges in conservation biology is to preserve genetic variability and adaptive variation within and among populations. However, habitat degradation and anthropogenic activity can affect the structure of natural populations causing changes in the spatial dynamics and the evolutionary dynamics shaping wild populations and can pose a serious threat to the natural evolution of biodiversity. The aim of current genetic studies, within the EREP project, is to unravel the genetic structuring of brown trout populations in some of the large freshwater catchment in Ireland, whose habitats have experienced major human-mediated changes over at least two centuries.

Since 2011 a number of brown trout genetics research programmes have been carried out under the EREP (Table 6.1 & Figure 6.1). These studies aimed to:

1. To establish the "status quo" in relation to the genetic diversity of trout stocks in each of these catchments.

2. To establish the extent to which trout from individual sub catchments contribute to the mixed adult stock in the main stem of both the Boyne and Suir catchments and to the lake in the Lough Corrib, Ennell and Sheelin catchments. This data would be of particular value in relation to the Boyne and L. Corrib, Sheelin and Ennell catchments where major enhancement programmes are underway. These studies may help to target sub catchments which are making little or no contribution to the trout mixed stock in the main stem/lake.

3. To determine the extent, if any, to which a major arterial drainage programme on the Boyne and Loughs Corrib, Sheelin and Ennell systems may have altered the genetic makeup of stocks. The Suir population, in this instance, will function as a "control system" because this is one of very few large Irish brown trout systems which was never subject to a major arterial drainage programme.

4. To look at the extent to which there may be discrete trout genetic groups within these catchments, despite the fact that they are not geographically isolated.

5. To establish "inter-family relationships" between discrete genetic groups of trout in each catchment.

Table 6.1. Brown trout genetics research programmes have been carried out under the EREP.

OPW Region	Catchment		Survey Year	Source of Funding
West	Corrib	Lake & rivers	2006/2007	IFI
West	Mask	Lake & rivers	2009/2010	IFI & Angling club
East	Boyne	Rivers	2011	OPW
East	Ennell (Brosna)	Lake & rivers	2011	OPW
Control	Suir	Rivers	2011	OPW
East	Sheelin (Inny)	Lake & rivers	2012	IFI, Angling Club & OPW
West	Corrib	Lake & rivers	2012	IFI & OPW
Southwest	L. Derg (Shannon)	Lake & rivers	2006-2009 & 2012	ESB, IFI, UCC, QUB, OPW

6.2 Some of the Fishery Management Implications

6.2.1 Boyne

1. Data suggests that the arterial drainage programme on the Boyne has had no significant impact on the genetic complexity of stocks. Trout populations in the Suir, a largely undrained system, are no more complex than those in the Boyne (see section 6.2.2).

2. This study has identified a very special genetic stock of trout in the Kells Blackwater – one of significant importance in conservation terms and genetic biodiversity.

3. While the information given in this report is based on data from one survey year (2011) it does provide a good insight into how the trout stock in the Boyne functions as an integrated unit and, for the first time, can quantify the role of its individual parts. This will allow one to protect channels of particular value and quantify their loss should problems arise.

4. These data will allow one to pin point the unproductive areas with a view to implementing enhancement programmes where possible.

5. In the longer term this technique will be a very effective tool for monitoring general fluctuations in trout stocks and, in particular, for assessing the long-term effectiveness of enhancement programmes.

6.2.2 Suir

1. A very high level of hybrids was found in all of the tributary populations except the Anner and the Drish rivers.

2. Gene flow seems to be significant in both an upstream and downstream direction for different genes within tributaries on the western side of the catchment.

3. The trout of main stem origin in the Suir seemed to be confined largely to the channel reach upstream of Holycross.

4. These data clearly illustrate that the trout population in the Suir main stem should be managed as a single fishery unit given its broad generic state.

6.2.3 L. Ennell Genetic Study

1. There is considerable genetic diversity among the wild trout stocks with identifiable populations in the individual stream sub catchments. One of the implications of these finding is that the arterial drainage programme on these streams, carried out in the 1950's, has had no significant effect on the genetics of these stocks.

2. The results of this genetic study showed clearly that a large scale stocking programme has had no long-term effects on the genetic stature of the wild trout stocks in this fishery.

3. The domesticated nature of the Roscrea trout probably account for their failure to influence the genetic makeup of the wild stocks.

Further details in relation to all of these studies can be found in the 2011 EREP Annual Report, or the scientific papers published (see section 6.4).

6.3 The Implications of the Genetic Studies to the EREP Project

These studies have a number of major implications for the EREP project;

1. These studies illustrate that the arterial drainage programmes carried out by OPW in these catchments in the past have not had a significant negative impact on trout stocks from a genetic perspective. Previous genetic studies carried out by IFI in relation to both the L. Corrib and L. Mask catchments also corroborate this trend.

2. The findings have greatly increased our understanding as to how the various sub populations of trout interact (or not) within the context of the overall stock. The results now enable one, with a greater degree of certainty, to predict how either an enhancement programme or, a drainage maintenance operation, in any particular area is likely to impinge on the overall fishery.

3. This fact will influence the selection of, and prioritisation of capital enhancement projects.

   These studies are helping to define "genetic strains of trout" which need to be regarded highly in conservation terms because of the number of private alleles evident in their individual genome.

4. Repeating some genetic studies over a period of years could prove to be a very useful tool in terms of measuring the effectiveness of capital enhancement works in terms of increasing trout populations.

6.4 Future

Going forward in to the next cycle of EREP (EREP 2013–2017) the Moy catchment and the additional L. Derg (Shannon) samples will be the subject of the next brown trout genetics study. Indeed the collecting of scale samples required for the genetic analysis is already well under way and the results should be available in late 2013.

Reports produced as part of all completed genetic studies are available to review and download through OPW's social text web page and include the following;

L. Corrib:	Patterns of genetic structuring in a brown trout (*Salmo trutta* L.) metapopulation (Massa-Gallucci *et al.*, 2010).
L. Mask:	A genetic study of the mixed trout populations of the Lough Mask catchment (Mariani & Massa-Gallucci, 2010).
Boyne:	A genetic study of the mixed trout populations of the Boyne and Suir River Catchments (Mariani & Massa-Gallucci, 2012).
Suir:	A genetic study of the mixed trout populations of the Boyne and Suir River Catchments (Mariani & Massa-Gallucci, 2012).
L. Ennell:	A genetic study of the mixed trout populations of the Lough Ennell catchment (Mariani *et al.*, 2009).

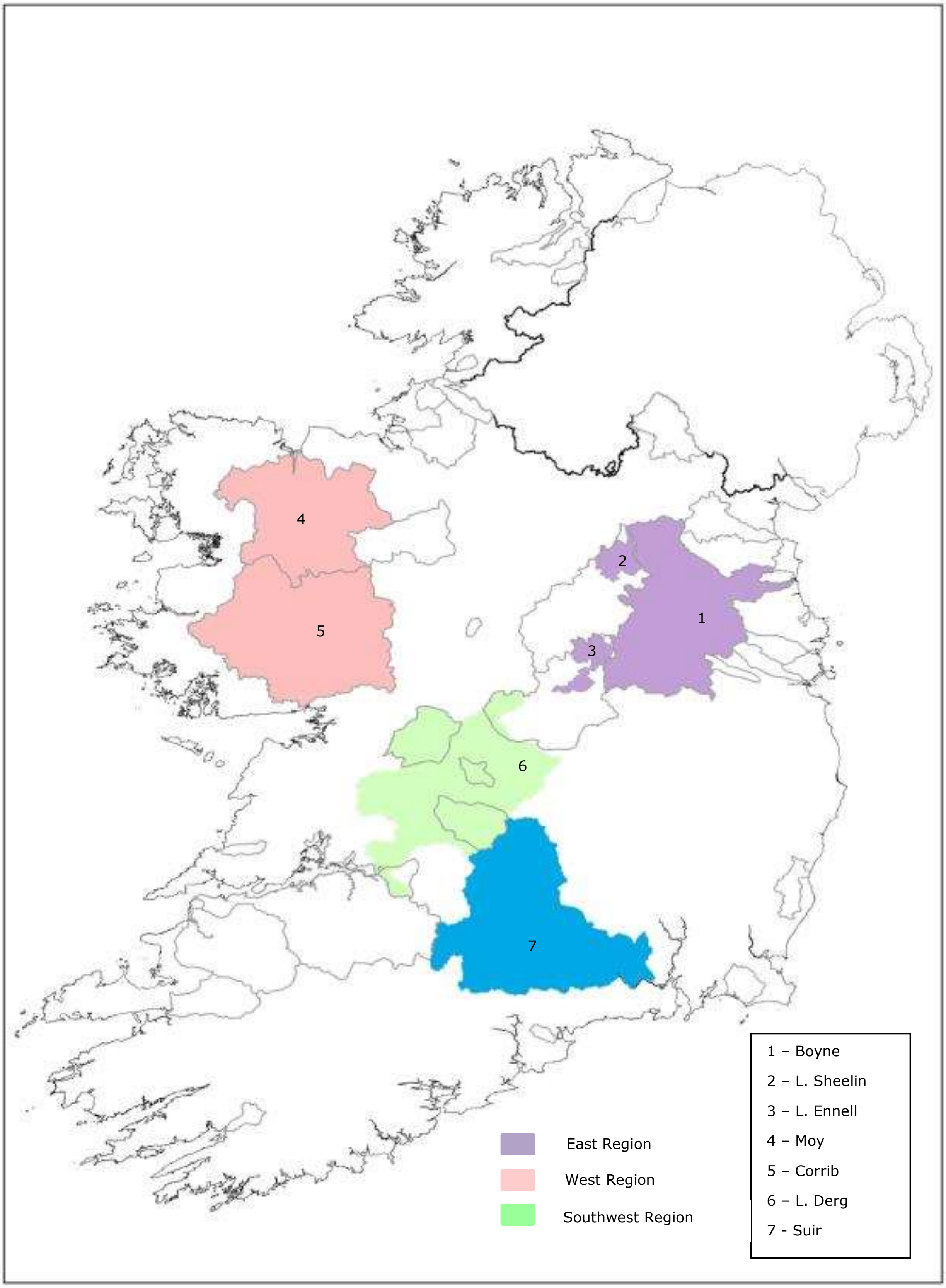


Figure 6.1. Brown trout genetic study catchments and OPW Drainage Regions.

7 EREP Audit Programme

Environmentally sensitive maintenance is seen by OPW as the way forward for all routine maintenance operations. This standard approach to maintenance applies to all channels at all times of the year. One of the objectives of EREP requires that a number of machine crew audits be carried out annually. Such audits will inform OPW to the level of compliance with these environmental measures. Audits will be undertaken internally by the Environmental Unit of OPW and externally by the EREP team of IFI. External auditing will cover a minimum of one third of all OPW drainage machine crews, annually. As drainage maintenance occurs through the whole year IFI auditing will also be spread out across the year. The majority of audits will, however, take place during the summer/autumn season or 'fishery open window', as this is the optimal time for implementing fishery instream works.

Machine crew auditing provides an opportunity for assessing the level of compliance with implementing OPW's environmental maintenance procedures. It also allows for further discussion and demonstration of certain maintenance options. Procedures for IFI auditing require the relevant foreman to be on-site during the assessment. The outcomes of the audit visit are compiled on the appropriate form and this is reviewed with the foreman at the end of the visit. A copy of the form is then forwarded to the relevant engineer (see Appendix III). All feedback on-site in relation to the audit is provided directly to the foreman and not the machine driver.

Auditing of machine crews provides OPW with up-to-date information on the level of compliance being achieved by their machine drivers and whether their staff are implementing as standard the environmental measures and protocols developed for routine drainage maintenance. Audit results are returned to OPW on a quarterly basis.

7.1 2012 Audit Results

In 2012, IFI carried out 29 external audits (Table 7.1), representing approximately 44% of all OPW maintenance crews. Audit outcomes are presented in figure 6.1. OPW has developed a rating system, based on the score obtained at each audit visit. This rating generates a series of board categories for rapid assessment of outcomes (Table 7.2)

Table 7.1. Number of audits carried out in each OPW Region, 2012.

		East	**West**	**South West**
Compliance Rating		**2012**	**2012**	**2012**
0-49	unacceptable			
50-59	poor	1		
60-70	acceptable	1		1
71-84	good	5	4	3
85-100	very good	5	5	4

Table 7.2. Summary of 2012 compliance ratings.

OPW % Rating	Category	2012 over-all %	No. of Audits
0 - 49	unacceptable	0	0
50 - 59	poor	4	1
60 - 70	acceptable	7	2
71 - 84	good	41	12
85 - 100	very good	48	14

The 2012 IFI audits results reported only 1 audit that was below the acceptable rating of 60%. The majority of audits were either in the good or very good category, representing 89% of all audits carried out across OPW regions. Mean compliance ratings amongst the three OPW regions recorded similar values, indicating performance across the regions is relatively stable (Table 7.3). Mean compliance for 2012 is somewhat down on the figures for 2011 (Table 7.4) especially within the 'very good' category.

Table 7.3. Summary of 2012 over-all % compliance ratings.

OPW Region	Mean % compliance
East	81
West	85
Southwest	85

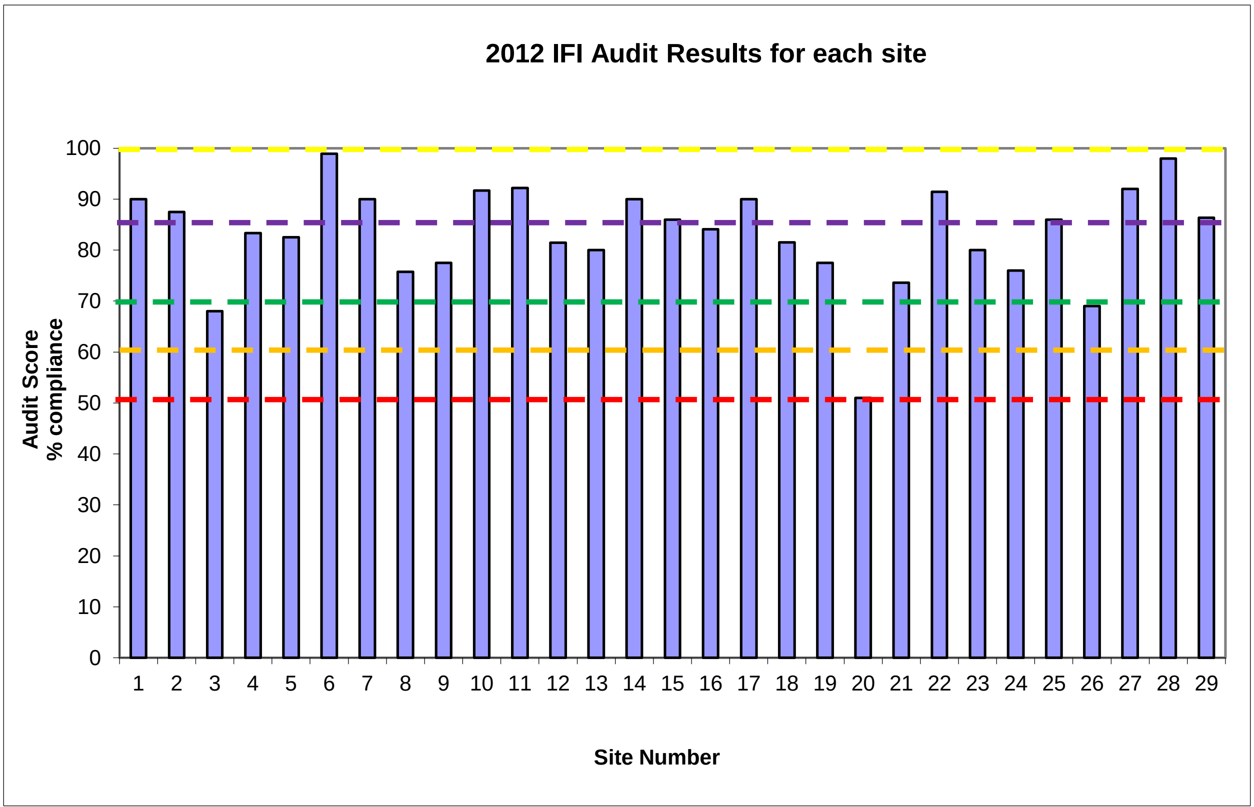


Figure 7.1. IFI external audit outcomes for each of the 29 sites, 2012.

Scoring of the individual options identified in the 10 Steps to Environmental Friendly Maintenance (see Appendix IV) is presented in Figure 7.2. The data recorded suggests relatively good overall implementation of the various maintenance options. Compliance percentages, amongst the various options scored, ranged from 55 to 100%.

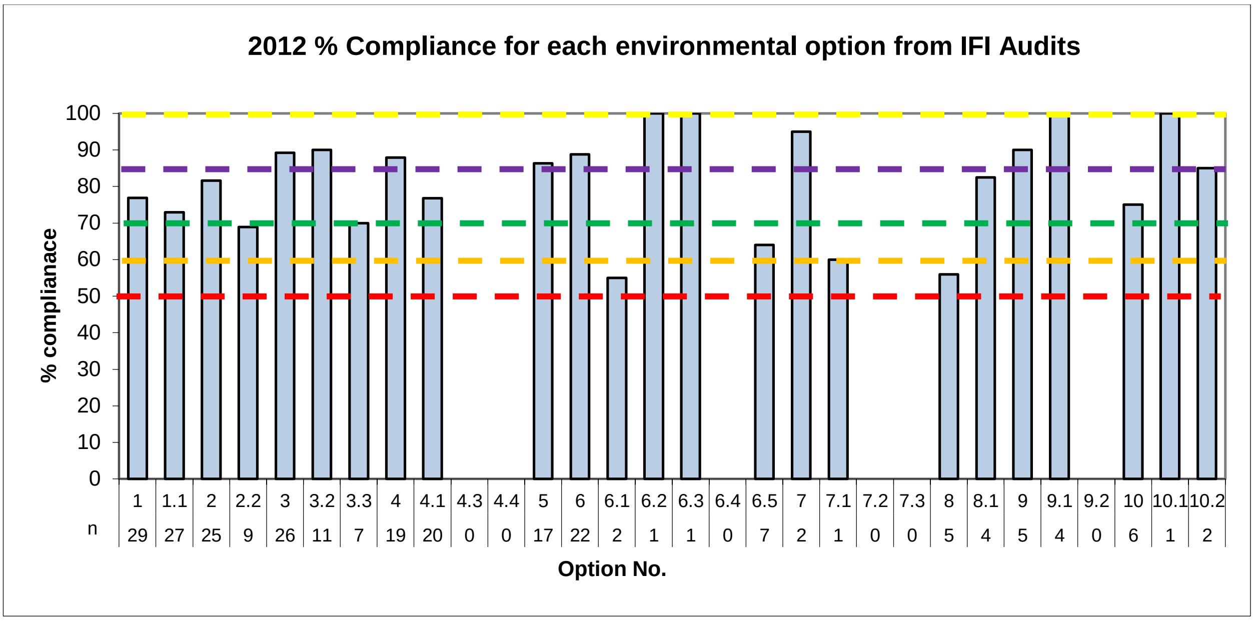


Figure 7.2. Percentage compliance from IFI audits, for each environmental option identified in the 10 Steps to Environmental Friendly Maintenance.

However, it should be noted that while the measures that were implemented were generally done so in an acceptable manner, a number of the channels were also suitable for other environmental options that were not carried out. The current audit form does not accurately reflect this. The results obtained through the IFI audits therefore only show the measures taken by drivers but not what the channel potential was. For the most part, options that may have been possible, but not implemented, are those associated with instream development work.

7.2 EREP Audit Review 2008–2012

In 2009 the audit review form was amended (Appendix III) therefore direct comparison with the 2009 - 12 audit findings is not feasible. Data presented here excludes the 2008 findings. The changes made to the EREP audit form now better reflect the compliance of OPW drivers towards environmental maintenance and their ability to recognise and implement the appropriate environmental maintenance options suitable at each site.

Comparison of the audit data available (Table 7.4 & Figure 7.3) indicates a lot of similarity amongst the three OPW Regions in terms of mean audit score, where individual audits for each region were averaged and present below. They also follow very similar patterns over the 4 years, 2009–2012.

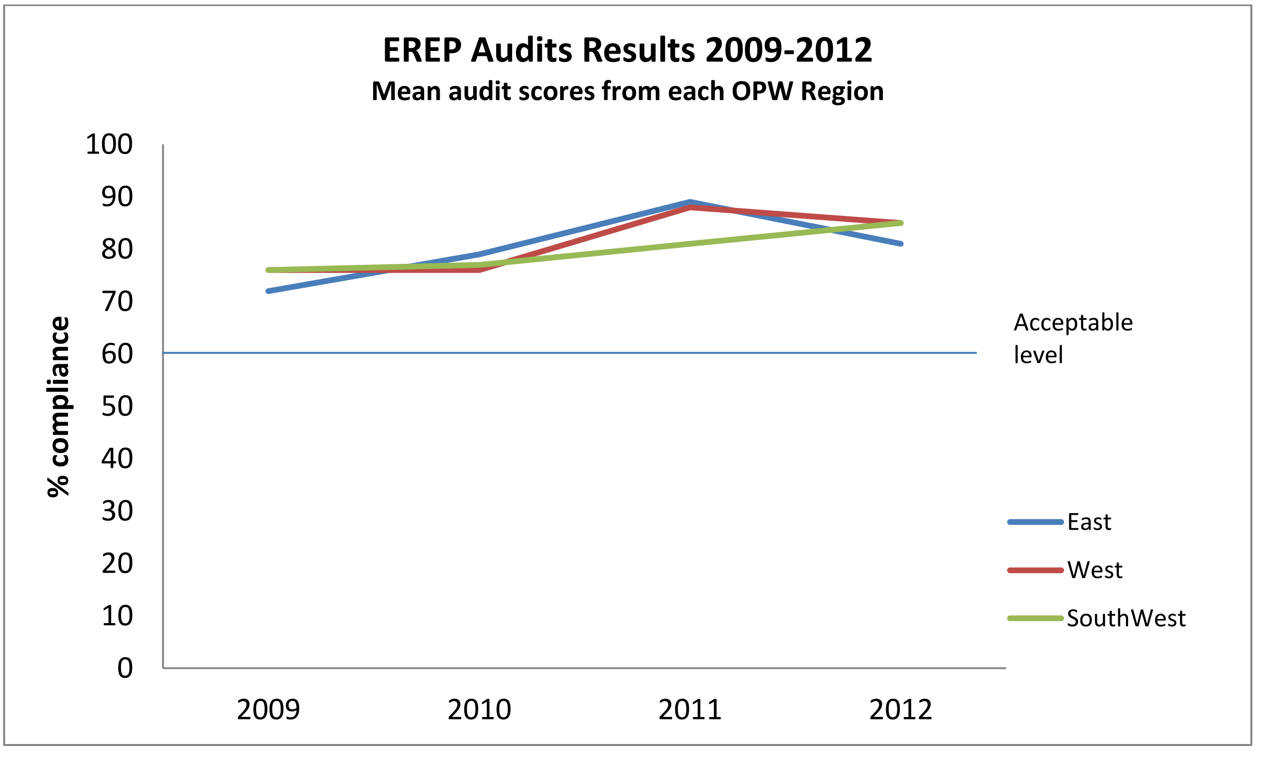
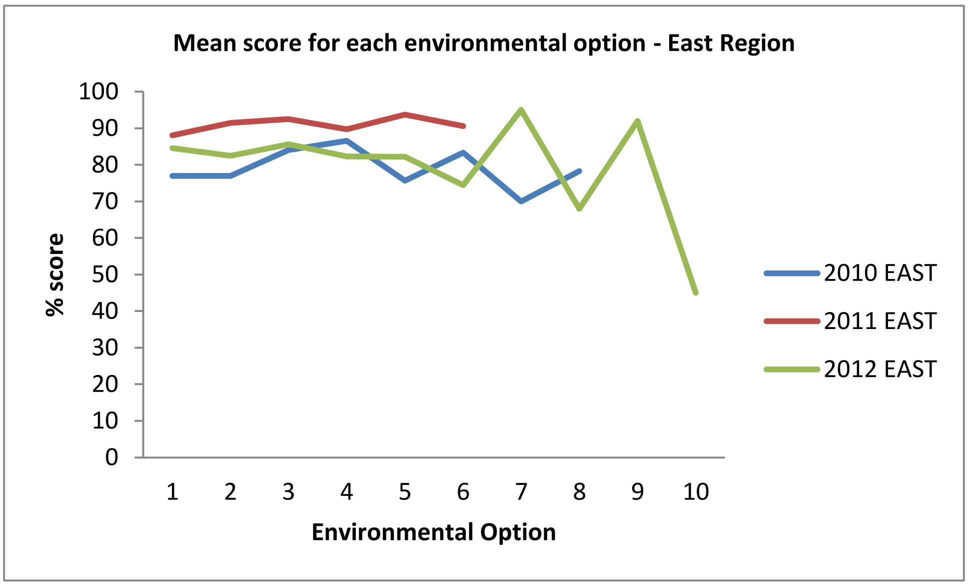


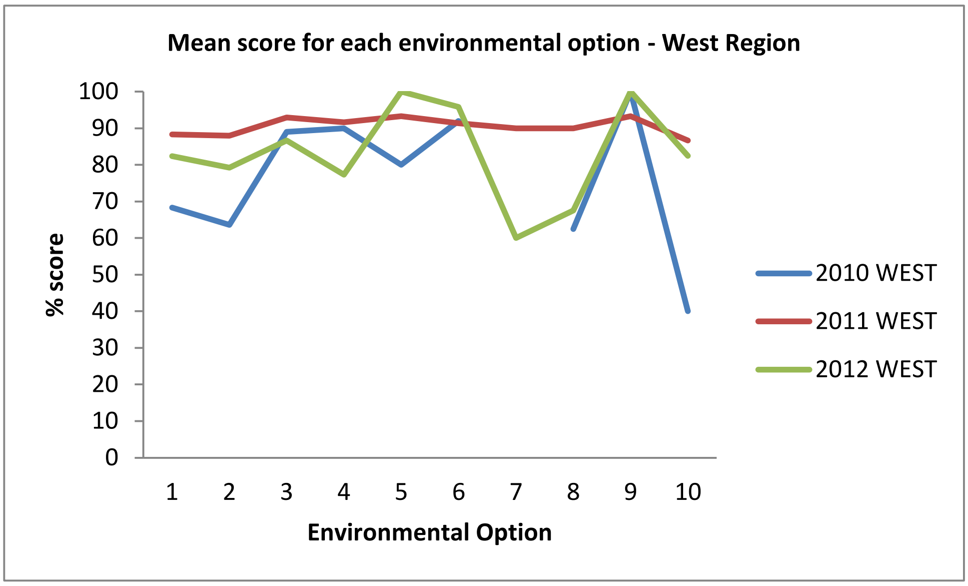
Figure 7.3. EREP audit results 2009-2012.

Table 7.4. Summary of the over-all mean compliance ratings, 2009-2012.

	2009	2010	2011	2012
East	72	79	89	81
West	76	76	88	85
SouthWest	76	77	81	85

However it is also important to look more closely at the individual scores obtained at each site and the results for each of the environmental options carried out by a driver. Here one can start to see fluctuations in the scores attributed to each environmental option. While there does seem to be some consistency amongst environmental options 1 to 5 however options 7 to 10 vary enormously each year and across regions. This would suggest that OPW drivers have a better understanding of what is meant by and how and where to implement these environmental options than they do the instream and marginal hydromorphology options of steps 7 to 10.





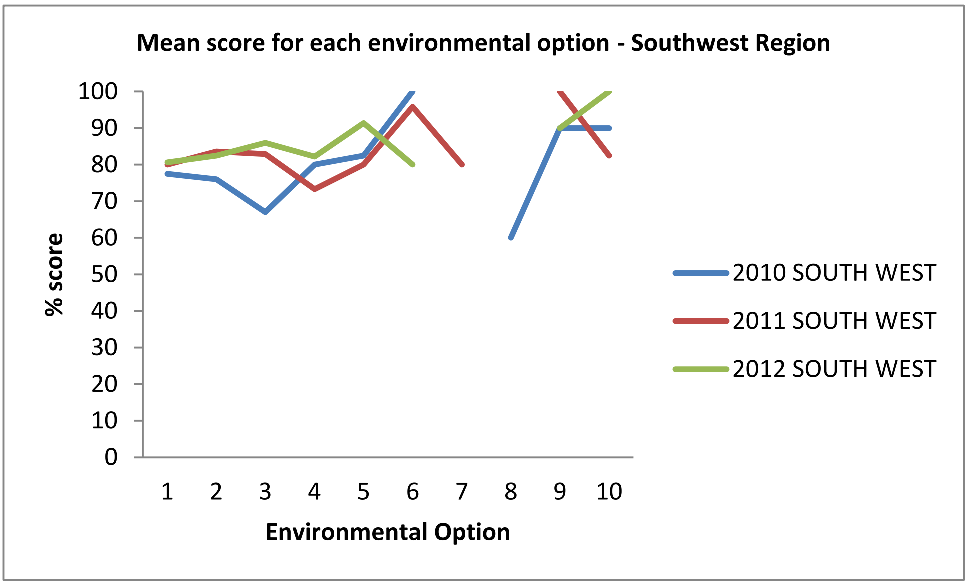


Figure 7.4. Mean score for each environmental option in each of the three OPW regions, 2010-2012.

8 OPW Training Programme

One of the required deliverables of EREP was the development and delivery of a training programme to OPW's field staff, involved in arterial drainage maintenance work, dealing with environmental issues in the river corridor. The training programme was successfully delivered in 2010. However a small number of additional training days were necessary in 2011 to accommodate new staff and those unavailable to attend in 2010.

The training programme delivered included presentations in river corridor biology and ecology, in maintenance strategies that machine drivers can employ in 'enhanced maintenance' and in the structures and strategies involved in the capital works element. An important part of the ecology element covered the series of Annex II species that machine drivers are likely to come across on a regular basis and what to do when these are encountered. OPW also took the opportunity to deliver a presentation dealing with their own Environmental Management Protocols and SOP's. OPW presentations were given by the local engineering section representative.

The formal approach to EREP training has to be complemented with on-site training. This has been and will continue to be a vital element of EREP. Support through regular site visits, audits and enhanced maintenance walk-overs should provide the active part of training. Advice through training manuals and information leaflets will also be available. A capital enhancement works manual already exists in the form of the 'Channels and Challenges' book (O' Grady, 2006). This is provided to all OPW foremen involved in capital works, and upon request to machine drivers. An updated version of the 10 Steps to Environmental Maintenance was issued in 2011 along with an updated version of OPW's own SOP's and Protocols guidance document to all OPW drainage maintenance staff.

Training is considered an important aspect of EREP if OPW staff are to achieve success in implementing environmental maintenance. OPW are committed to ensuring all staff meet the needs of EREP and are fully briefed in relation to their own SOP's and environmental protocols. Therefore the development and training necessary to implement environmental measures in relation to all aspects of OPW drainage maintenance will be provided to all existing and new OPW field staff on a regular cycle of 3 to 5 years. This may take the form of 'refresher' courses and/or full training sessions as is required.

Plate 8.1. OPW training.

9 River Hydromorphology Assessment Technique (RHAT)

The Water Framework Directive (WFD) requires information on hydromorphological conditions, along with biological quality and physico-chemical conditions, in order to determine the ecological status of any given waterbody. A classification of 'High Ecological Status' cannot be assigned to a water body unless the hydromorphological conditions are high also. If the hydromorphological condition of a waterbody has not been determined and the system has been impacted by drainage then that catchment is deemed to be "probably at risk". Therefore it has become an additional objective of EREP to provide information on hydromorphology status in relation to OPW channels.

The River Hydromorphology Assessment Technique (RHAT) monitoring system has been approved as the appropriate method to determine hydromorphological status of a channel and is being used by the EPA and the NIEA (Northern Ireland Environment Agency) to assess hydromorphological (hydromorph) condition at those sites identified for WFD monitoring.

RHAT surveys score a site based on eight individual channel attributes (NIEA, 2009). These scores then provide a hydromorph score which in turn determines the WFD class of that site (Table 9.1).

Table 9.1. Conversion of RHAT scores to WFD Class.

Hydromorph Score	WFD Class	RHAT Score
> 0.8	high	4
> 0.6 - 0.8	good	3
> 0.4 - 0.6	moderate	2
> 0.2 - 0.4	poor	1
< 0.2	bad	0

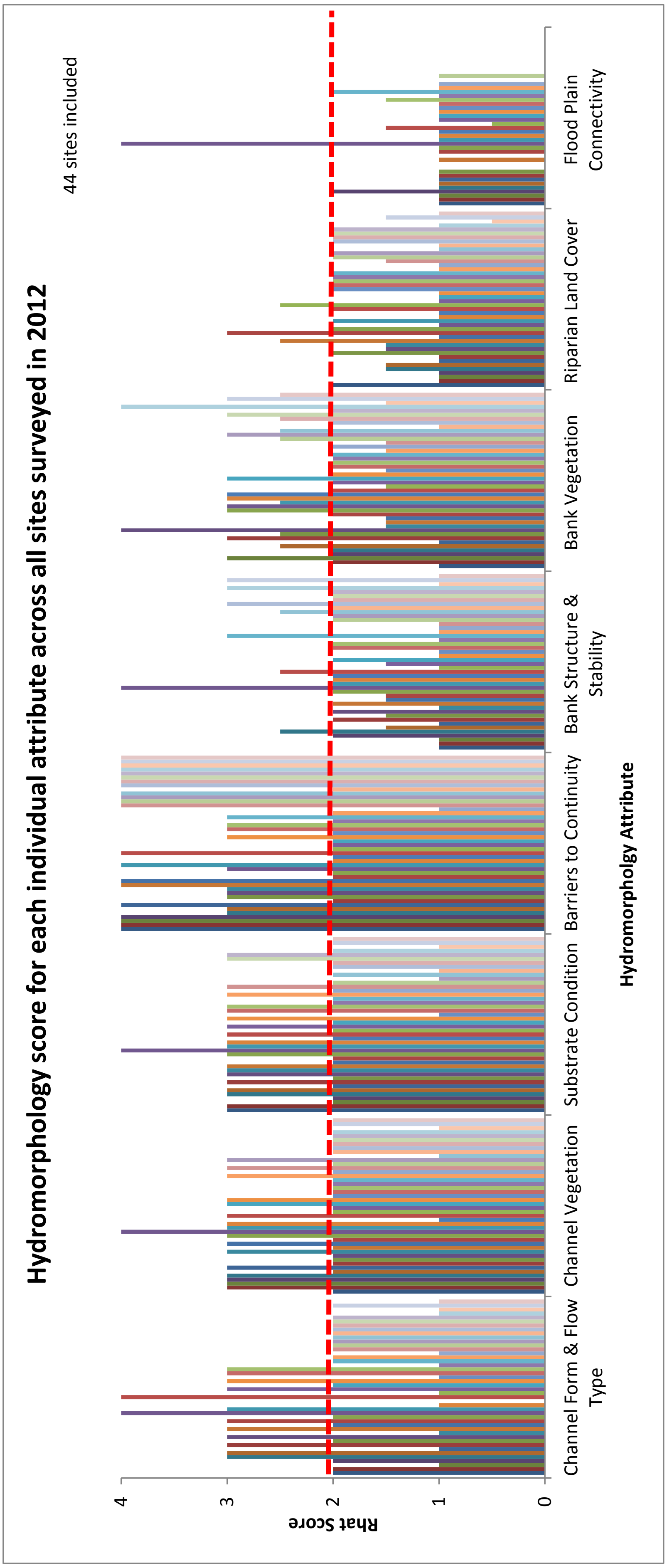
A total of 44 RHAT surveys were carried out in 2012 (Table 9.2). A number of surveys were 1 year post works, the majority were pre works surveys.

Table 9.2. RHAT survey results 2012.

WFD Status	Total Count 2012	% contribution
High	1	2
Good	2	4
Moderate	35	80
Poor	6	14
Bad	0	0

A high percentage of sites recorded a WFD rating of moderate for hydromorphological status even prior to any capital works or enhanced maintenance works being carried out.

An over-view of the individual scores for each attribute at each site surveyed (Figure 9.1) indicates which channel attributes are failing ecological status and helps determine what enhancement requirements can contribute to achieving good/high WFD status. In the majority of sites surveyed barriers to continuity is the only channel attribute that does not seem to be a major issue. While 50% of sites showed substrate composition not to be an issue and 44% of sites suggesting that channel vegetation is relatively suitable. However for all other channel attributes scored a large number of sites surveyed are at or below moderate. Of these attributes there is very little enhancement potential for floodplain connectivity or with riparian land cover. Bank structure & stability and channel form & flow type are two areas where improvements could be achieved through EREP. The review of Physical Survey outcomes (Section 3.6) clearly identified the potential for EREP measures to generate a diversity of instream channel form and flow conditions.



(Red line indicates cut off point, below this value a WFD class of good or high will not be achieved)

Figure 9.1. Hydromorph score for each individual attribute across all sites surveyed in 2012.

As the RHAT scoring system is based only on a 4 point scale changes noted amongst individual channel attributes can often go undetected when the final RHAT value is presented. Therefore it was considered important to monitor and show the changes across each of the 8 individual channel attributes scored pre and post works (Figure 9.2). Channels which underwent capital works generally showed an improvement in channel form and flow type post works. This is as a direct result of the type of enhancement options carried out within these channels. Channels where enhanced maintenance was carried out indicate that the type of maintenance implemented did impact negatively on channel vegetation and substrate condition initially. However 1 year post enhanced maintenance both these attributes have improved on even the pre works condition. Full implementation of OPW’s new environmental protocols, by machine drivers, should help reduce such impacts.

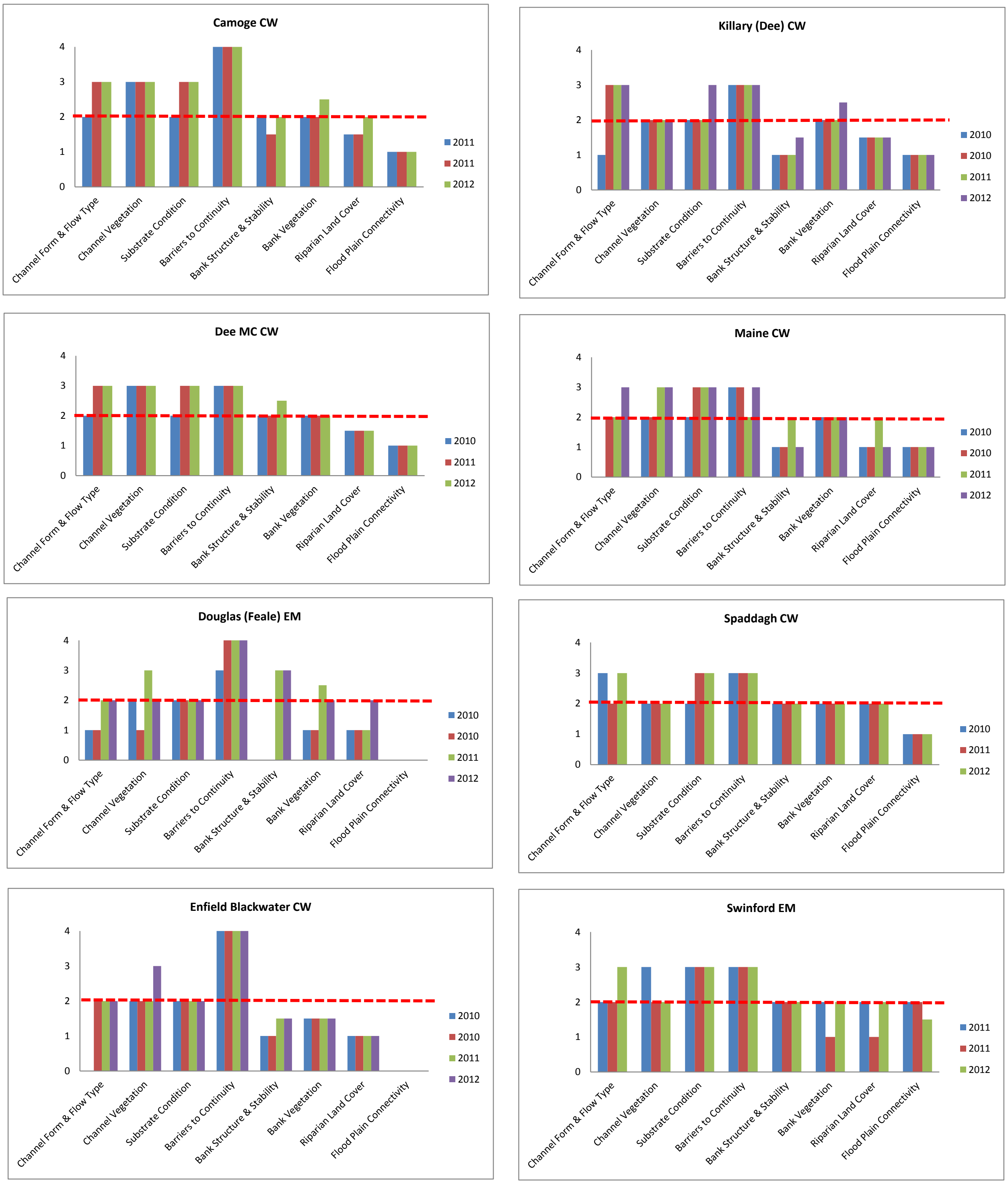


Figure 9.2. RHAT channel attributes scored pre and post EREP, 2010-2012.

9.1 Review of RHAT Surveys

Over the last three years RHAT surveys have become a part of EREP. Where possible a RHAT score is obtained for sites which are identified for both capital works and enhanced maintenance. The initial survey is pre works which is then followed up with an immediate post works and then where possible annually. It is expected that for some of the 8 RHAT variables measured that there will be some negative impact on the channel immediately following works. However within a year the changes due to either programme should be making a positive contribution, in particular those involving capital works and to a lesser extent those that underwent enhanced maintenance and these changes should be evident through the RHAT surveys post works.

Table 9.3. Summary of RHAT survey sites, pre and post enhanced maintenance and capital works, 2009-2012.

OPW Region	Catchment	River Name	OPW channel code	EREP type	pre RHAT	Immediately post works	1 yr post works	2 yr post works
East	Dee & Glyde	Dee	C2(1)	CW	Moderate	Moderate	Moderate	
East	Dee & Glyde	Killary (Dee)	C2(28)	CW	Moderate	Moderate	Moderate	Moderate
East	Boyne	Enfield Blackwater	C1/36	CW	Poor	Moderate	Moderate	Moderate
Southwest	Maigue	Camoge	C1/25	CW	Moderate	Moderate	Good	
Southwest	Maine	Maine	C1	CW	Poor	Moderate	Moderate	Moderate
Southwest	Maine	Maine	C1/36	CW	Moderate	Moderate		
West	Moy	Spaddagh	C1/35	CW	Moderate	Moderate	Moderate	
East	Boyne	Knightsbrook	C1/16	EM	Moderate	Moderate	Moderate	Moderate
East	Broadmeadow & Ward	Ward	C2	EM	Poor	Moderate	Moderate	
Southwest	Feale	Douglas	C1/18/17	EM	Poor	Poor	Moderate	
West	Corrib Clare	Milltown	C3/32	EM	Moderate	Moderate		
West	Mask	Robe trib	CM4/50	EM	Moderate	Poor		
West	Mask	Millstream	CM4/43	EM	Moderate	Poor	Moderate	
West	Moy	Swinford	C1/39	EM	Moderate	Moderate	Moderate	

While the individual scored variables of RHAT may reflect the EREP works carried out, when the overall RHAT score is calculated the changes achieved through the enhancement programmes are often not so obvious. That is the RHAT or hydromorph score may not have changed at all following implementation of either capital works or enhanced maintenance. The type of channels that would benefit mostly from EREP works are those that are in the higher range of the 'Moderate' group. It is very likely that capital works undertaken in those channels within the upper 'Moderate' class would successfully move into the 'Good' class. Carrying out EREP works in channels with an existing 'Poor' or 'Bad' ecological classification status is unlikely to change the ecological status of that channel. However it should be stated that enhancement works carried out would address the hydromorphological issues of that channel. This though may not be enough to alter the ecological status of the channel, especially if the water quality of the channel is a bigger issue than the hydromorphological condition.

The over-all role of hydromorphology for use in determining ecological status is less important than the other elements used to determine status, mainly water quality and fish. Therefore if the enhancement works carried out through EREP result in improvements in fish numbers the site is likely to upgrade its ecological status based on this rather than the RHAT survey results. Hydromorphology alone cannot bring down the ecological classification of a river, only in the case of a high to good status and nothing else.

References

Ebrahimnezhad. M. and Harper, D. M. (1997). The biological effectiveness of artificial riffles in river rehabilitation. Aquatic Conservation: Marine and Freshwater Ecosystems, 7: 187–197.

Harper, D., Ebrahimnezhad, M. and Climent I, F. (1998), Artificial riffles in river rehabilitation: setting the goals and measuring the successes. Aquatic Conservation: Marine and Freshwater Ecosystems, 8: 5–16.

Haslam, S. M. (1977). River plants: the macrophytic vegetation of watercourses. Cambridge University Press, New York, 3: 45.

Haslam, S. M., Purseglove, J. and Watt, G. A. (1997). The river scene. Ecology and cultural heritage. Cambridge University Press, 8: 217.

Hunter, C. J. (1991). Better trout habitat – a guide to stream restoration and management. Montana Land Reliance, Island Press, Covelo, California, 308.

I.F.I. (2009). Environmental River Enhancement Programme Annual Report, 2008. Inland Fisheries Ireland, Dublin, Ireland.

I.F.I. (2010). Environmental River Enhancement Programme Annual Report, 2009. Inland Fisheries Ireland, Dublin, Ireland.

I.F.I. (2011). Environmental River Enhancement Programme Annual Report, 2010. Inland Fisheries Ireland, Dublin, Ireland.

I.F.I. (2012). Environmental River Enhancement Programme Annual Report, 2011. Inland Fisheries Ireland, Dublin, Ireland.

Kelly, F., Champ, T., McDonnell, N., Kelly-Quinn, M., Harrison, S., Arbuthnott, A., Giller, P., Joy, M., McCarthy, P., Cullen, P., Harrod, C., Jordan, P., Griffiths D., and Rosell, R. (2006). Fish stock assessment for the water Framework Directive: investigation of the relationship between fish stocks ecological quality ratings (Q-values) environmental factors and degree of eutrophication. Environmental RTDI Program 2000 – 2006. Environmental Protection Agency (2000-MS-4-M1).

King J. J., Hanna, G. and Wightma,n G. D., 2008. Ecological Impact Assessment (EcIA) of The Effects of Statutory Arterial Drainage Maintenance Activities on Three Lamprey species (Lampetra planeri Bloch, Lampetra fluviatilis L., and Petromyzon marinus L.). Series of Ecological Assessments on Arterial Drainage Maintenance No 9 Environment Section, Office of Public Works, Headford, Co. Galway.

King, J. J., Lordan M., and Wightman, G. D. (2008). Ecological Impact Assessment (EcIA) of The Effects of Statutory Arterial Drainage Maintenance Activities on White clawed Crayfish *(Austropotamobius pallipes)*. Series of Ecological Assessments on Arterial Drainage Maintenance No. 10 Environment Section, Office of Public Works, Headford, Co. Galway.

Maddock, I (1999). 'The importance of physical habitat assessment for evaluating river health',

Freshwater Biology, 41, 2, pp. 373-391.

Mariani, S., Massa-Gallucci, A. (2009). A genetic study of the mixed trout populations of the Lough Ennell catchment. IFI Report.

Mariani, S., Massa-Gallucci, A. (2010). A genetic study of the mixed trout populations of the Lough Mask catchment. IFI Report.

Mariani, S., Massa-Gallucci, A. (*2012*). A genetic study of the mixed trout populations of the River Boyne and Suir catchment. IFI Report.

Massa-Gallucci A., Coscia I., O'Grady M., Kelly-Quinn M. and Mariani, S. (2010). Patterns of genetic structuring in a brown trout (*Salmo trutta L*) metapopulation. Conservation Genetics, 11: 1689–1699.

Moog, O. (Ed.) (2002). Fauna Aquatica Austriaca - Edition 2002. Wasserwirtschaftskataster, Bundesministerium fur Land- und Forstwirtschaft, Unwelt Und Wasserwirtschaft, Vienna. Federal Ministry of Agriculture, Forestry, Environment and Water Management Stubenring 1, A-1010 Vienna.

N.I.E.A. (2009). River Hydromorphology Assessment Technique (RHAT) - Training Guide. Northern Ireland Environment Agency, Lisburn, Northern Ireland.

O'Grady, M. F. (2006). Channels and Challenges. The enhancement of salmonid rivers. Irish Freshwater Fisheries Ecology & Management Series: No. 4, Central Fisheries Board, Dublin, Ireland.

O'Grady, M. F. and O'Leary, C. (2007). Irish Fisheries Recovery Dataset Provision. Programme of Measures and Standards – Freshwater Morphology. Central Fisheries Board.

O.P.W. (2011). Environmental Management Protocols and Standard Operating Procedures, Arterial Drainage Maintenance Service, Office of Public Works.

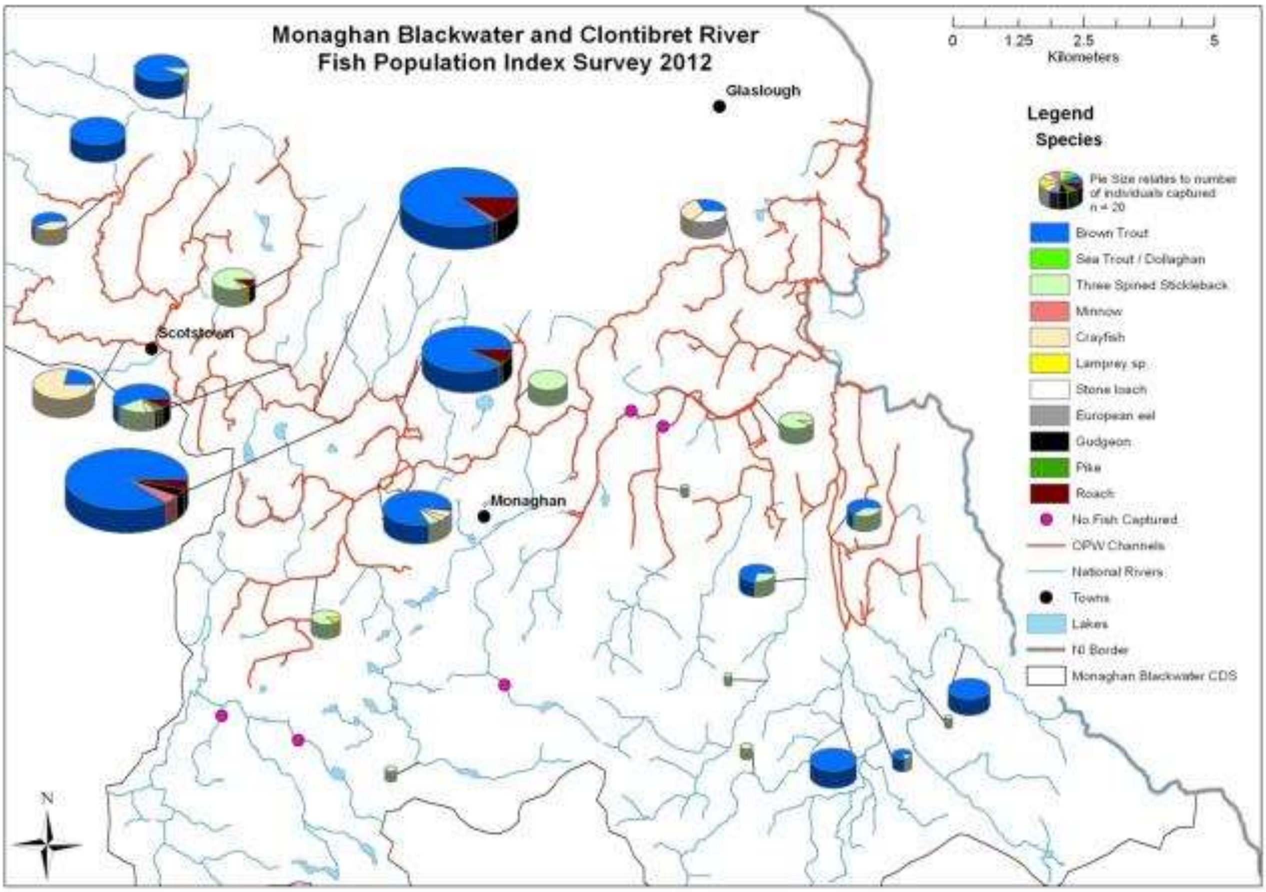
Q.E.D. V. 1.1.3.456, Statistical software package. Pisces Conservation Ltd.

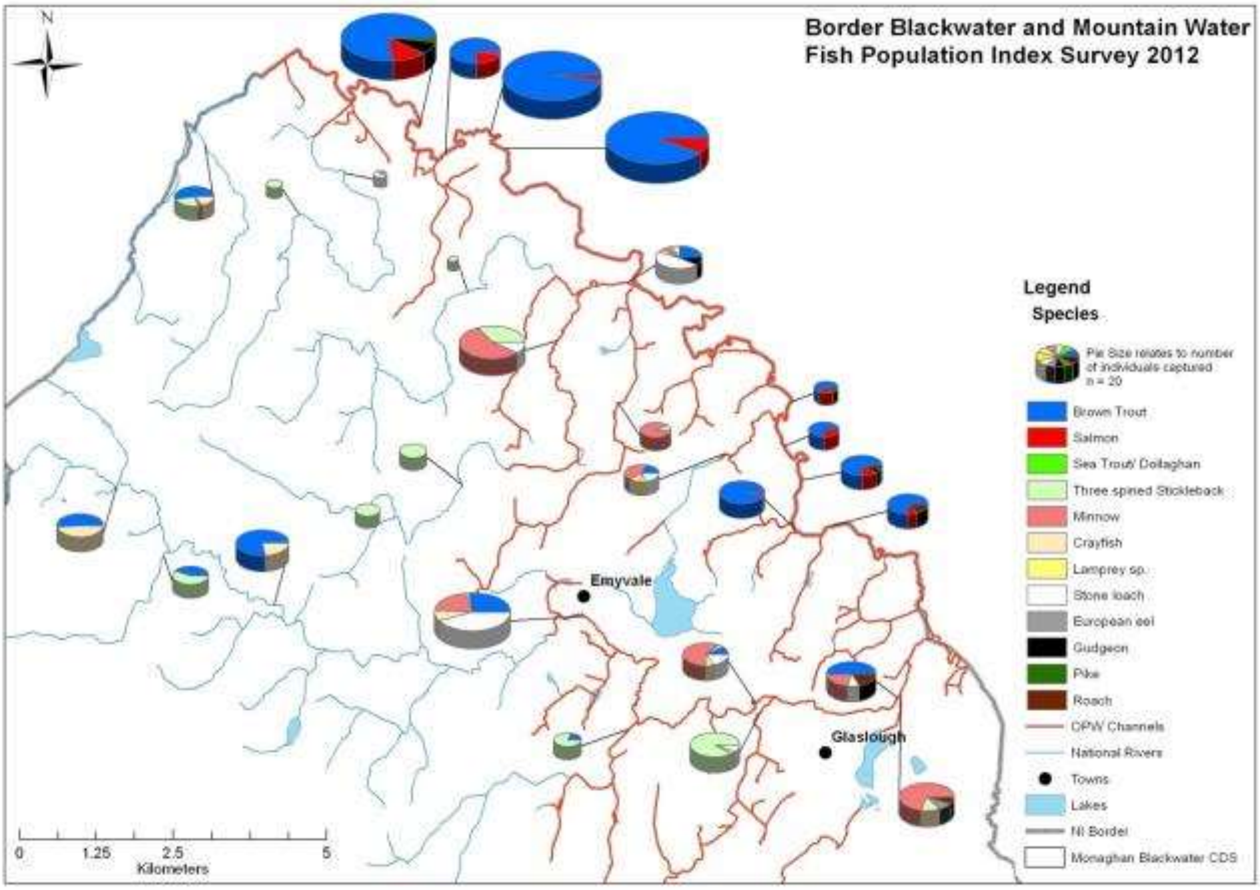
Whiteway, S.L., Biron, P. M., Zimmermann, A., Venter, O. and Grant, J. W. A. (2010). Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences, 67: 831–841.

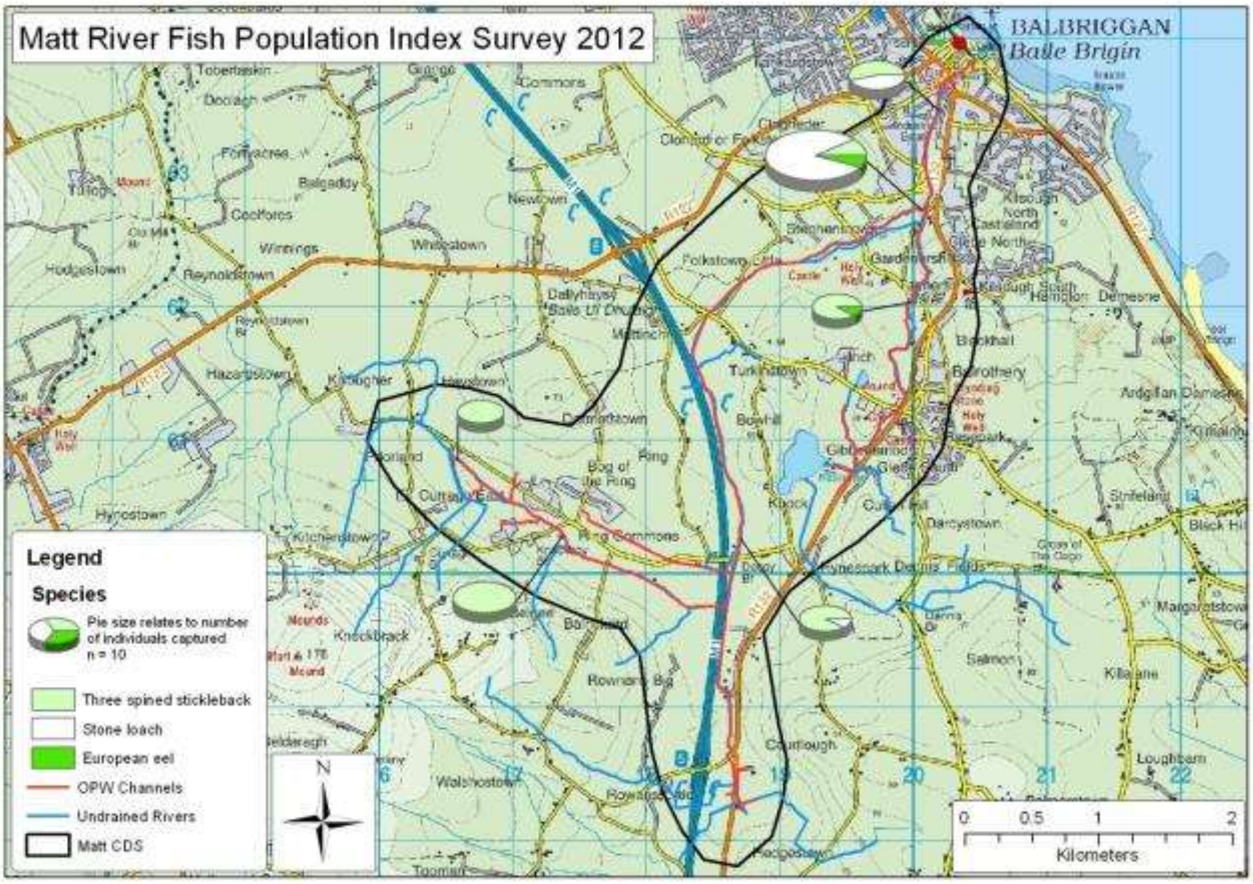
Appendices I - IV

APPENDIX I

FPI Monaghan Blackwater and Matt Maps






Matt River Fish Population Index Survey 2012
BALBRIGGAN
Baile Brigín
Legend
Species
Pie size relates to number of individuals captured n = 10
Three spined stickleback
Stone loach
European eel
OPW Channels
Undrained Rivers
Matt CDS
N
0 0.5 1 2
Kilometers

Appendix II

Bird Survey Methodologies

Birds can be a very significant element in the biodiversity of a river corridor and those present are likely to be impacted by OPW drainage maintenance or indeed to any disturbance within the river ecosystem.

In general, standard bird survey methods used by Bird Watch Ireland and other relevant agencies were applied. Some minor adjustments were made to the standard recording forms, to fit the project requirements. For the purpose of this survey three methodologies were utilized; a 500m walking line transect, a 5km walking line transect and 5km canoe line transect method.

The 500m walking line transect method involved two observers standing on opposite banks, beginning at predefined starting points and walking 500m in a fixed line along the river bank in a slow steady pace, whilst recording all the adult birds seen or heard within relevant distant bands. The distance bands utilized left and right of the transect line are <5m, 5-10m, 10-15m, 15-20m, 20-25m and >25m. Each distance band reflects the perpendicular distance from the transect line to the individual bird recorded. The position of the river within the relevant distant bands was also recorded.

In order to accurately reflect both the migratory and resident populations in Ireland, a two stage sampling programme was undertaken. The first of the two visits conducted at each waterway, was undertaken from mid April to mid May. This reflects the abundance of residents and early migrants observed in Irish waterways. The second survey from mid May to mid June, reflects the later migrants in waterways. A minimum period of four weeks was left between the two surveys. It is important that both sampling periods, and all subsequent surveys to a site, were undertaken by the same observers where possible, to minimise the likelihood of error. Each survey began shortly after dawn and finished at approximately 10am, to coincide with the period of greatest bird activity. Additionally, in order to facilitate accurate gathering of data, surveys were conducted only on days with relatively dry and calm weather conditions.

To facilitate accurate recordings of observed birds, each transect was further sub-divided into five 100m sections. Hand-held GPS instruments and maps were used to mark the start and end of each 100m section. Every effort was made to ensure that each bird was recorded in the 100m section they are first observed and that each bird is recorded only once. Birds not conclusively identified were omitted.

Data collected at each site was pooled into one survey sheet. Additionally behaviours such as nesting, aggression, feeding and bathing were also recorded by each observer. Birds in flight were recorded separately, although birds that are usually seen in flight, such as house martins (*Delichon urbicum*), sand martins (*Riparia riparia*) and swallows (*Hirundo rustica*), which use the river habitat or the surrounding area, were recorded within the appropriate distant band. Additionally, birds which were seen outside the sampling transect, for instance behind the observer, were only recorded in the additional species section of the data sheet. Site variables were also recorded at each site - these include drainage history, width of channel, vegetation stratification profile and bank slope features. For the purpose of this survey the river corridor encompasses both the river and the bank full on both banks.

In 2010 the bird survey programme was expanded to include control sites in undrained channels. This was undertaken firstly to determine if there are significant differences in the abundance and distribution of waterway bird species in drained versus undrained channels. And secondly to examine the natural population fluctuations within channels which have no arterial drainage.

To test the effectiveness of the 500m methodology in identifying riparian bird community/species richness associated with a particular channel; in 2011 a new sampling methodology was incorporated which involved the use of 5km walking line transect summer bird surveys. The 5km survey length was adapted so that species such as the kingfisher whose territories stretch over several kilometres have a great probability of detection. The standard methodology used for the 500m surveys was again utilized for the 5km survey, with a number of minor variations. For instance these surveys took place from 8am to 6pm to coincide with the period of maximum activity of waterway bird species. To facilitate accurate recordings of observed birds, each transect was further sub-divided into fifty 100m sections, thus enabling pre and post maintenance impacts to be determined for any future OPW works. While these surveys were aimed at recording riparian bird species, particularly species such as the dipper which were missed during the 500m early morning surveys; all species seen within the distance bands were recorded. For the 5km surveys, the distance bands utilized left and right of the transect line were in the river, <5m, 5-10m, 10-15m and >10m.

One visit was made to each waterway in late July. Where possibly, sites were chosen in areas where previously surveyed 500m surveys sites could be incorporated into the 5km transect. Where this was feasible, the distance bands used in the 500m survey were once again employed for that stretch, thereby enabling comparison with the earlier two stage sampling programme.

As the 5km walking line transect surveys proved so efficient at gathering riparian bird survey information, in 2012 the method was further expanded to incorporate 5km canoe line transects. The use of a two person Canadian canoe allowed the quick and efficient collection of data. It also enabled areas which were previously in accessible by foot to be surveyed. The standard methodology employed in the 5km walking line transect surveys were utilized, with a number of minor adjustments. For instance, the distance bands employed left and right of the transect line were in the river, <5m, 5-10m and >10m. In addition, while two individuals were in the canoe at all times, only the master observer recorded details about the birds and habitat. The secondary observer’s task was that of rowing and navigation. For health and safety a shore backup person was utilized at all times to maintain phone and visual contact at predetermined points. Surveys took place from 8am to 2pm to coincide with the period of maximum activity in riparian and waterway bird species.

In order to accurately reflect both the migratory and resident populations in Ireland, a two stage sampling programme was undertaken. The first visit was undertaken from mid April to mid May. And the second survey from mid May to mid June. However, due to poor weather conditions the second survey was unachievable in the majority of the canoe sites. This however was taken into account during data analysis. Where possible, canoe sites were chosen in areas which were previously surveyed using the 500m walking line transects. Where this was feasible, the 500m walking survey was completed and followed by the 5km canoe survey, thereby enabling comparison with the earlier two stage sampling programme.

In order to give a more accurate representation of species richness in both drained and undrained channels, an ‘Additional Bird Sightings’ database was established in 2010. This database recorded all bird species observed in the river corridor by the EREP team outside formal surveys. This was similar to the roving records sampling programme adopted by Bird Watch and involved recording all bird species observed in the river corridor, together with associated GPS location and date. This data allowed a more accurate representation of species richness in channels as it was not restricted to either specific breeding seasons or time of day.

APPENDIX III

AUDIT FORM

OPW Site Audit Form

Region: ______________________ **CDS:** ______________________

Channel (name & code):__________________ Section (chg – chg):__________________

Foreman: ______________________ Driver(s): ______________________

Auditor: ______________________ **Date:**______________________

Site surveyed from- working bank: ☐ non-working bank: ☐

GPS Reference:______________________ Photographs: Yes ☐ No ☐

Weather Conditions:__________________ Water levels: ______________________

Wetted/Base width: 0-3m ☐ 3-6m ☐ 6-10m ☐ 10-15m ☐ >15m ☐

Velocity Rating: Slow ☐ Moderate ☐ Fast ☐ Torrential ☐

Bed Type: ______________________ Machine Number:______________________

OPW SOP AWARENESS / COMPLIANCE

Invasive Species SOP:	Poor / Fair / Good / Excellent
Protected Species SOP's:	Poor / Fair / Good / Excellent
Spill Kit Present:	YES / NO

Environmental Drainage Maintenance Constraints

Maintenance Constraints			Working Bank	Non Working Bank
Ownership:	Woodland			
Ownership:	Tillage			
Ownership:	Position of Fencing			
Availability of suitable stone				
Placement of spoil				
Time of year:	Tree cutting			
Time of year:	Wildlife			
Time of year:	Fisheries			
Potential Habitat for Annex II Species		Lamprey		
		Crayfish		
		Otter		
		Pearl mussel		
		Salmon		

Comments on Audit Findings

Maintenance Strategies Achieved - *(based on section recently maintained)*							
	Maintenance Options	**Working Bank**		**Non-working Bank**		**Instream Channel**	
		Suitability	Compliance*	Suitability	Compliance*	Suitability	Compliance*
1	**Protect Bank Slopes**						
	Non-working bank left intact						
	Protect working bank slope						
2	**Restrict Maintenance to Channel**						
	Restrict maintenance to open channel						
	Use of SOPs for lamprey and crayfish						
3	**Spoil Management**						
	Best practice placement of spoil						
	Spread spoil thinly						
	Let water drain from bucket over channel						
4	**Selective Vegetation Removal**						
	Manage instream vegetation (Attn SOPs)						
	Retain marginal vegetation both sides						
	Potential for weed cutting bucket						
	Outside coarse fish spawning *(April 1st to July 1st)*						
5	**Leave Sections Intact**						
	Sections skipped						
6	**Management of Trees**						
	Remove trees blocking flow						
	Observe tree cutting window						
	Remove low hanging branches to known flood level						
	Use chainsaw/secuters for tree removal or thinning						
	Tree thinning management						
	Manage scrub - Otter & Birds SOP						
7	**Manage Berms to form 2 Stage Channels**						
	Retain berms (no maintenance)						
	Top berm to just over summer water flow						
	Re-sod berms where suitable						
	Only narrow berms if OVER-WIDE						
8	**Replace Stone & Boulders**						
	Replace stone and gravel coming out in digging bucket (No New Diggings)						
	Replace large stones/boulders into channel from old spoil						
9	**Working in Gravel Bed Channels**						
	Loosen/toss gravels *(between July 1st & Sept. 30th)*						
	No instream works outside of Fisheries Window *(between July 1st & Sept. 30th)*						
	Use of silt barriers in winter/spring						
10	**Re-profile Channel Bed**						
	Dig pool - riffle sequences						
	Reprofile cross-section						
	Use existing stone to create 'simple' instream structures						

*based on rating system: 0-10, with 0=no compliance and 10=full compliance

Total Compliance (%)

OVERALL COMPLIANCE (%)

APPENDIX IV

10 STEPS GUIDELINES

Environmental Strategies for Channel Maintenance

OPW

1. Protect bank slopes

1.1 Do not disturb the non-working bank slope

1.2 Minimise any effect on working bank

1.3 Leave margin of vegetation at foot of each bank slope

2. Restrict maintenance to channel

2.1 Remove only necessary silt – **<u>no new diggings</u>**

2.2 Remove instream material only

2.3 Retain marginal vegetation

2.4 Check spoil regularly. ***See Lamprey & Crayfish SOPs***

3. Spoil Management

3.1 Maximise spoil placement on bank full line or spoil heaps

and

3.2 Minimise spoil placement on bank slopes

3.3 Spread spoil as thinly as possible

3.4 Allow water to drain out of bucket over the water – lets small fish, lamprey and crayfish escape

Iascach Intíre Éireann
Inland Fisheries Ireland

March 2011

Environmental Strategies for Channel Maintenance

OPW

4. Selective Vegetation Removal

4.1 Retain a band of vegetation on both sides at water's edge

4.2 Selectively manage instream weeds

4.3 Maximise use of weed-cutting bucket

4.4 Avoid maintenance in coarse fish channels from April 1st to 1st July

4.5 Retain 1/3 to ½ of instream floating type vegetation, such as *Ranunculus* (water crow foot – see photo below)

5. Leave sections untouched

5.1 If channel capacity is not affected, leave section alone

Iascach Intíre Éireann
Inland Fisheries Ireland

March 2011

Environmental Strategies for Channel Maintenance

6. Management of Trees

6.1 Remove trees that are blocking the flow

6.2 Tree-cutting window 1st September to 28th February

6.3 Remove overhanging branches to known flood level

6.4 Use saw secateurs for removal, not excavator bucket

6.5 Manage trees to reduce very heavy shading

6.6 Manage briars and scrub.
See Otter SOP

Iascach Intíre Éireann
Inland Fisheries Ireland

March 2011

Environmental Strategies for Channel Maintenance

OPW

7. Manage berms to form two-stage channels

7.1 Remove top of berms to low flow levels

7.2 Remove vegetation and soil from gravel berms

7.3 Replace sod to the berm where feasible

7.4 Only narrow berms if 'excessively' wide for the channel (i.e. greater than a third of the channel width

8. Replace stone and boulders

8.1 Reinstate boulders and gravels as removed by maintenance operations

8.2 Reinstate suitably sized boulders into channel from spoil heaps where feasible

8.3 Boulders should be placed at or below low flow level and spaced out

9. Work in gravel bed channels

9.1 Loosen or toss bed gravels to wash out fines

9.2 Only considered between 1st July and 30th September

9.3 No work in gravel bed / spawning channels in fisheries 'closed season'
Note: This varies locally check with local IFI

Iascach Intíre Éireann
Inland Fisheries Ireland

March 2011

10. Re-profiling channel bed

10.1 Excavate bed to form deeper pool areas and shallow riffles

10.2 Over-deepen the channel along one side and place spoil on opposite side –particularly on curves and bends

10.3 Use existing boulders to form **simple** low-level structures

10.4 Record where such works are carried out

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

Web: www.fisheriesireland.ie
Email: info@fisheriesireland.ie

Tel: +353 1 8842 600