Environmental River Enhancement Programme

Annual Report 2016

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Iascach Intíre Éireann
Inland Fisheries Ireland

EREP 2016 Annual Report

Inland Fisheries Ireland & the Office of Public Works

Environmental River Enhancement Programme

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:

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Environmental River Enhancement Programme Annual Report 2016

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1 Introduction

The 2015 report indentified how changes to the EREP study would be implemented, in the light of re-structuring within IFI's R&D unit. The reduced degree of cover was continued in 2016 with a number of core activities on-going – the Capital Works design programme for 25 km of works; the auditing programme; scientific studies.

The Capital Works component is particularly manpower-intensive in regard to identification of suitable sites, development of individual site-specific plans and inspection and oversight during works phase. While plans were developed by IFI in respect of 29 km of channel for 2016, the current report indicates that only 8 km of works were achieved by OPW. The report highlights other shortcomings in this element of the EREP study.

The auditing process was fully supported by the civil foremen. Twenty audits were carried out, spread among 8 of the civil foremen across OPW's three regions. As in previous years, there was a high level of compliance with several of the very basic environmental guidance strategies. However, the extent of implementation of Topic 10, undertaking new diggings, remained low even in situations where this strategy was feasible in terms of bed gradient and bed material. There is considerable scope for OPW to avail of this Topic as a measure to improve the hydromorphology of channels, in the context of Water Framework Directive implementation. Advancing this measure requires greater effort by OPW at engineer and foreman level in each OPW region - it cannot be left to individual audit visits.

A limited suite of scientific studies was completed, including extended-term monitoring of brown trout and habitat in the Tullamore Silver, first surveyed by IFI in 1990, and a catchment-wide fish and hydromorphology study on the R. Bonet. IFI's R&D team also undertook a catchment-wide survey of larval lamprey in the Bonet catchment in 2016 as part of its reporting procedures for the EU Habitats Directive and the findings are included here. OPW has expresed a wish that IFI would compile outcomes of its studies on crayfish and impacts of maintenance into a peer-review scientific publication. To further this aim, IFI re-surveyed four channels where studies had been conduicted in the 2006 – 2012 period. IFI also re-surveyed the R. Robe site where crayfish were monitored as part of a Capital Works programme.

The process of assessment of fish passability of barriers, in planning for potential Capital Works projects under EREP, was continued in 2016 with SNIFFER assessment of individual structures in the Brosna and Cappa-Kilcrow catchments undertaken.

2 EREP Capital Works Overview: 2016

Throughout 2016 a number of river enhancement programmes were carried out under Capital Works which involved a site specific plan of instream development work. In total 17 individual catchments and 21 individual rivers were identified for enhancement works (Table 2.1). The location of these works is shown in Figure 2.1. Several of these EREP capital work projects were either only partially completed or not achieved in 2016 and where possible these channels will be included in the programme of works for 2017.

The Capital Works strand of EREP identified approximately 29km of channel for works in 2016 (Table 2.1). Of this target almost 7km was completed (Table 2.2).

Table 2.1. Channels identified for EREP Capital Works for 2016

OPW Region	Scheme	River	Channel Code	Plan length (m)	Plan availal
East	Dee	Dee	C2(1)	1000	yes
East	Boyne	Kells Blackwater	C1/8	600	yes
East	Boyne	Boyne mc Navan	C1	200	yes
East	Boyne	Boyne mc Derrinydaly Br	C1	2500	yes
East	Boyne	Boyne mc d/s of Ballyboggin Br.	C1	2000	yes
East	Dodder FRS	Dodder		500	yes
East	Inny	Yellow (Inny)	C43	1300	yes
East	Brosna	Silver (Brosna)	C3(1)	500	yes
East	Owenavorragh	Owenavorragh	C1	2600	yes
Southwest	Killimor	Kilcrow	C1	1270	yes
Southwest	Nenagh	Ollatrim	C1	800	yes
Southwest	Maigue	Loobagh	C1/34	1250	yes
Southwest	Maigue	Flemingstown	C1/34/12	500	yes
Southwest	Deel	Arra	C12	500	yes
Southwest	Feale	Feale (Shanow Br)	C1/18	100	yes
Southwest	Maine	Maine	C1	2300	partial
Southwest	Maine	Glanshearoon	C1/35	1300	partial
West	Abbey	Abbey	C1	2600	yes
West	Moy	Moy trib Stirabout Br	C1/57	1500	yes
West	Moy	Trimogue	C1/30/5	570	yes
West	Corrib Headford	Houndswood	CH8/1	300	yes
West	Clare	Grange	C3/9	1800	yes
West	Corrib	Drimneen	CH10	650	yes
West	Corrib	Drimneen trib	CH10/3	1100	yes
West	Corrib	Drimneen trib	CH10/4	450	yes
West	Corrib	Drimneen trib	F201	600	yes

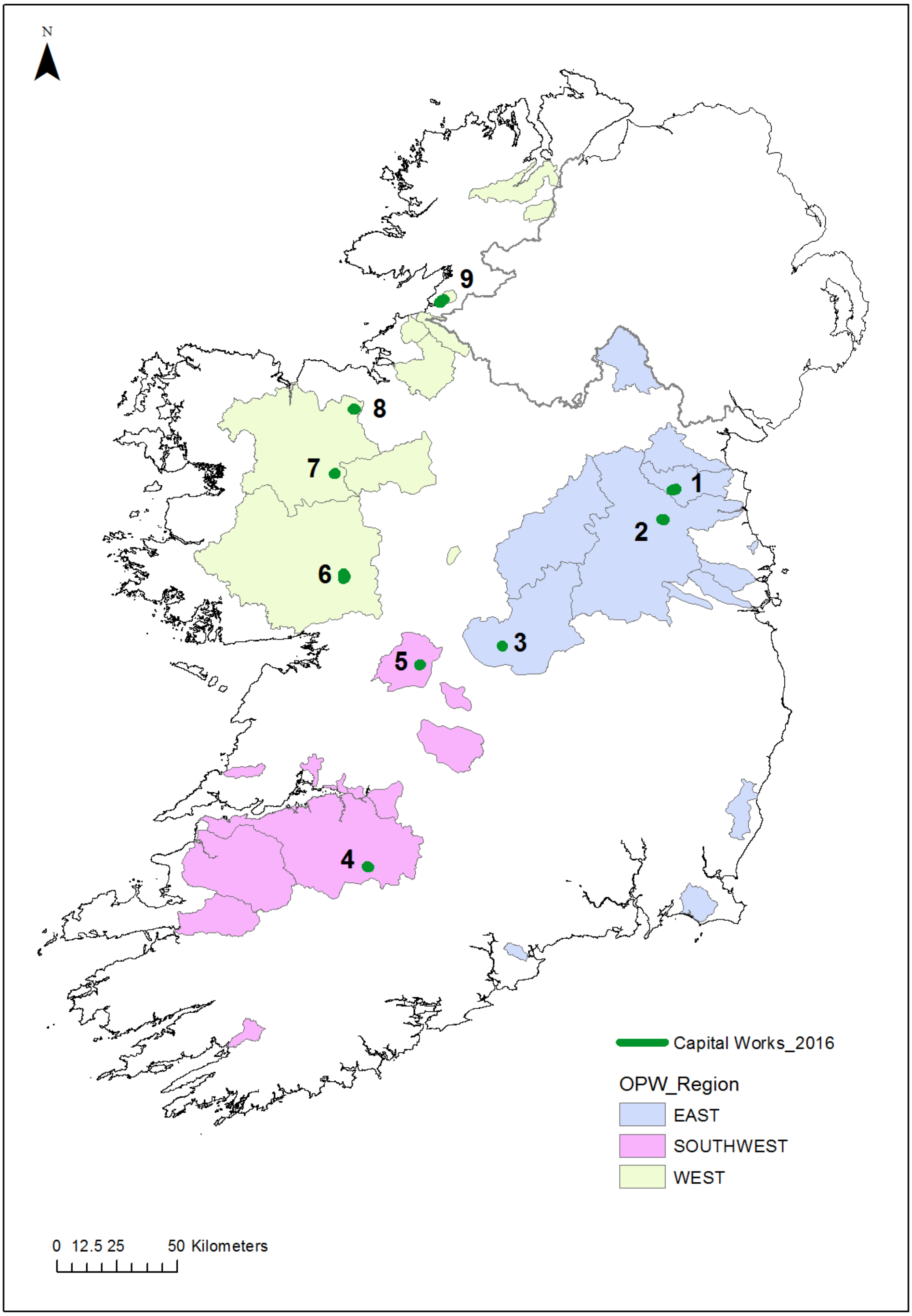

Figure 2.1. Location of EREP Capital Works programmes, 2016.

Of the Capital Work programmes started in 2016 only 2 were fully implemented, the other 7 were only partially completed but will be scheduled for completion in 2017.

Table 2.2. Status of Capital Works for 2016

Id	OPW Region	Catchment	River	Channel Code	Status	Target Length (m)	Achieved Length (m)
1	East	Glyde & Dee	Dee R.	C2(1)	Partial	1000	900
2	East	Boyne	Kells Blackwater	C1/8	Partial	600	500
4	Southwest	Maigue	Loobagh	C1/34	Partial	1250	600
5	Southwest	Killimor	Kilcrow	C1	Outstanding	1270	800
6	West	Corrib	Grange River	C3/9	Outstanding	1800	400
7	West	Moy	Trimogue R	C1/30/5	Complete	570	570
8	West	Moy	Cloonbaniff Steam	C1/57	Outstanding	1500	500
9	West	Abbey	Abbey River	C1	Complete	2600	2600

Table 2.3. Summary of EREP Targets and Achievements for Capital Works, 2016

OPW Region	Target (km)	Set (km)	Achieved (km)	% achieved (of plans)	% achieved (of target)
East	10	9	1.4	15.5	14.0
Southwest	7	8.0	1.4	17.5	20.0
West	8	9.6	4.1	42.7	51.3
Total	25	26.6	6.9	25.9	27.6

Even though the Capital Works element of EREP has been withdrawn from the over-all project from 2017 onwards the OPW hope to be in a position to continue with Capital Works through alternative means. While this process is being addressed the OPW intend to complete existing programmes on those channels where existing plans are available.

There was a reduced progress on the Capital Works element of EREP in 2016 and a number of factors have played a part in this including the work load of OPW in dealing with other ‘flooding issues’ in effect reducing the labour and machinery resource available from the drainage maintenance service for capital enhancement works. In parallel, the reduced staff resources that IFI were able to provide to the project reduced the scale of assistance and supervision that IFI could offer to OPW at implementation stage. It was evident that these factors led to a reduction in the overall distance of capital works completed. Reduction in the traditionally strong levels of communications between OPW and IFI and the associated site supervision meant that design changes arising during the construction were not always agreed in advance and that some of the changes did not always achieve the maximum environmental gain. In other cases, there was a satisfactory implementation of agreed works designs.

Examples are presented below to show both types of outcomes:

River Dee, C2(1): the addition of gravel shoals was not successful in that the shoal design and gravel size and composition were inappropriate (see Figure 2.2 and 2.3). There was a local constraint with sourcing the correct gravel material and *in lieu* of the shortfall in material, OPW maximised the use of the existing channel bed material. However this was not suitable for the purpose of gravel shoals and will require to be removed or reconstructed with an imported gravel material.

Figure 2.2. Dee River - Inappropriate spawning gravel shoals shape/design.

Figure 2.3. Gravel shoal at tail of pool with paired deflector Dee River.

River Kilcrow: The capital enhancement works were carried out in tandem with local flood improvement works which entailed rock breaking a length of the channel to relieve a flood risk to adjoining properties. Significant changes were required to the designed Capital Works enhancement plan to accommodate the changes due to the flood improvement works. While the streamlining of works for channel enhancement and flood relief is entirely appropriate it is unfortunate that IFI was not notified of these proposed changes prior to their implementation. Prior consultation might have led to altered river enhancement design that would have benefitted the final outcome.

Figure 2.4. Rock breaker working on the Kilcrow R. Ballycahill Bridge.

River Loobagh (c1/34 Maigue CDS): A section of channel in this river had been identified as a potential site for experimental river restoration techniques such as the reinstatement of a cut off meander and the reuse of felled trees for bank protection (Fig. 2.5 – 2.7). However the opportunity was missed as maintenance proceeded without these experimental options being revisited when works commenced.

Figure 2.5. Berm management and bank protection work Loobagh R., pre works

Figure 2.6. Berm management and bank protection work Loobagh R. post works.

Successful Capital Works were achieved on the Abbey River (Donegal) (Figure 2.8 and 2.9) and Trimogue (Moy) rivers and works carried out on the Grange (Corrib), Loobagh (Figure 2.10) and Cloonbaniff stream (Moy) showed good examples of instream structures.

Figure 2.8. Appropriate spawning gravels and location on the Abbey R.

Figure 2.9. Examples of alternating deflectors Abbey R. implemented in 2016.

Figure 2.10. Good example of a paired deflector, pool and gravel shoal, Loobagh River.

The dvelopment of a series of ‘how to’ video clips for a range of instream development techniques used in Capital Works continued in 2016. This programme of work is being carried out through an external contract working with both OPW and members of the EREP team in IFI. The video clips will capture the various stages of implementing each technique from start to finish. It is hoped these ‘how to’ video clips will be available through the OPW ‘al fresco’ system to all OPW staff, once completed.

3 Auditing Programme – Implementation of Enhanced Maintenance procedures

3.1.1 General

A total of 20 audits were undertaken in 2016, using the new form developed between IFI and OPW. (Table 3.1) Comparison of results of audits in 2015, using the old and new forms, had indicated a broad concurrence in results. The new form is designed to compile more detail and to tease out and score for specific issues.

Table 3.1. List of audits undertaken in 2016 by IFI under the EREP study

OPW Region	Foreman	Catchment	Channel	No. Audits
West	Jarlath Mc Hugh	Boyle	C1	2
			C1/11	
		Bonet	C1/3/4	2
			C1/3	
	Paddy Moyles	Moy	C1/21/1/5/2/13/1	3
			C1/30/7/16/1	
			C1/30/5	
East	Martin Myers	Glyde-Dee	C25/1	1
		Monaghan B.W.	C1/16	1
	Barry Murphy	Owenavaragh	C1	1
	Paddy Leavy	Boyne N	C1/32/7/2	3
			C1/8/15/10	
			C1/15	
	Willie Kenny	Brosna	C9/1	2
			C3/13/A	
South-west	Ger Aberton	Maigue	C1/25/23	2
			C1/30	
	Tadhg Roche	Deel	C8/1	2
			C1	
		Maigue	C1/17/6	1
				Total 20

As in previous years, the auditing was distributed among the three OPW regions. It was originally planned to visit a larger number of foremen and their crews, as in previous years. However, in several catchments foremen had to revise their programmes and divert their crews to flood repair works and no ‘regular’ maintenance was thus scheduled in these cases. IFI views the audit process as a two-way exchange between the foreman and EREP staff, the EREP examining the opportunities for and implementation of the various relevant training points from the 10- step guidance notes of OPW. On-site discussion with the foreman covers issues, problems of implementation, positives and negatives. The audit visit also allows an opportunity to trial relevant measures that the drivers may not be implementing. The drivers may also identify issues on-site and problems with implementing certain strategies, as well as identifying how they have adopted certain measures to suit the specific site and its issues.

Given the extent of small channels (4’ base width type) within the various OPW arterial drainage schemes it was not surprising that many audits were done in channels of 1 – 3 m width, or less. A comparison of channel sizes examined in 2015 and 2016 identified a predominance of the smaller sized channels (Figure 3.1). However, there was some representation of other channel sizes. It was clear, both from prior experience and from the current audits, that there are limited options for value-added works in small-width channels. The experience is, generally, that drivers implement ‘habitat retention’ measures relating to protection of the two bank slopes, minimise diggings, managing spoil and managing of the tree and shrub line along the channel in these smaller channels.

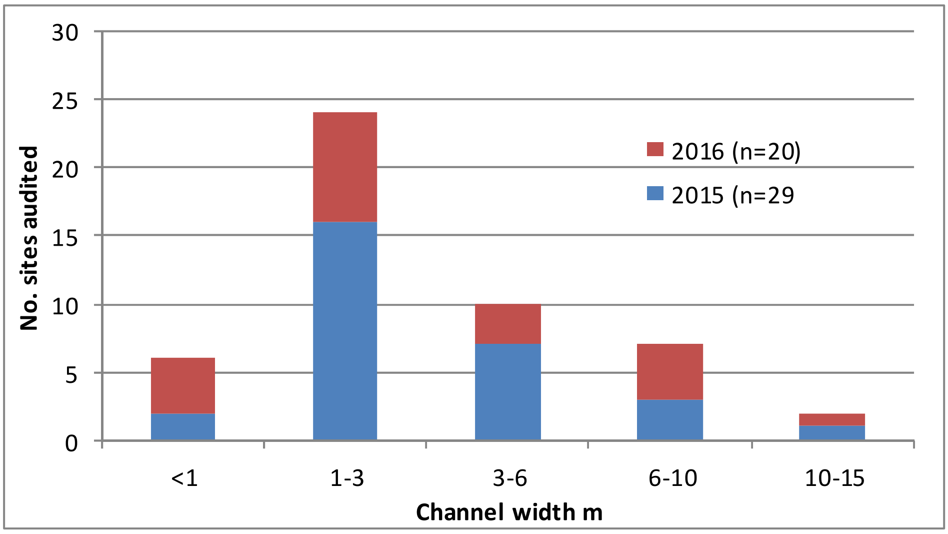

Figure 3.1. Distribution of sites audited, by channel width, in 2015 and 2016

At present, the auditing is organised through IFI arranging with an individual foreman to link up on a specific day, The type of sites/channels visited are entirely dependent on where the OPW machine crews of that foreman happen to be at the time of visit. In order to achieve an increased roll-out of more pro-active measures, such as the 'new excavations' compiled in Item 10 of the environmental guidance, IFI requested foremen attending the annual review meeting in 2016 to contact IFI directly if one of their machine crews was operating in a channel with potential for new diggings. No such contacts were made during 2016. This option does have potential to optimise interaction of the EREP team with foremen on-site at locations where significant 'added-value' could occur.

3.1.2 Distribution of scoring – overall scores and distribution among the performance categories

An overview of the 2016 audit outcomes pointed to a similarity with those of 2015 (Figure 3.2). There was predominance of scores in the 'Very Good' category in both years i.e. greater than 85% score. There were four 'Bad' scores (<50%) recorded in 2016 whereas there was only one 'Bad' score, of a total of 29 visits, recorded in 2015.

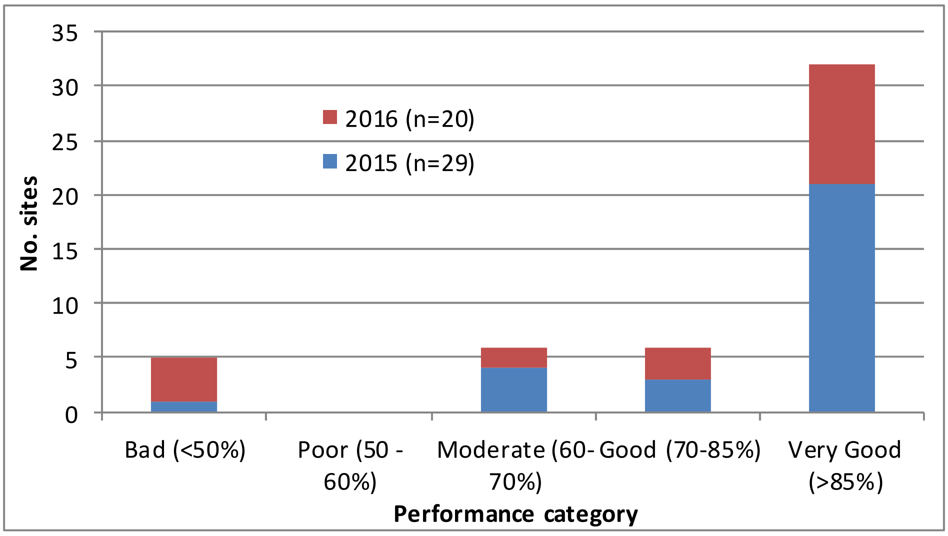

Figure 3.2. Distribution of audit scores among performance categories, 2015 and 2016.

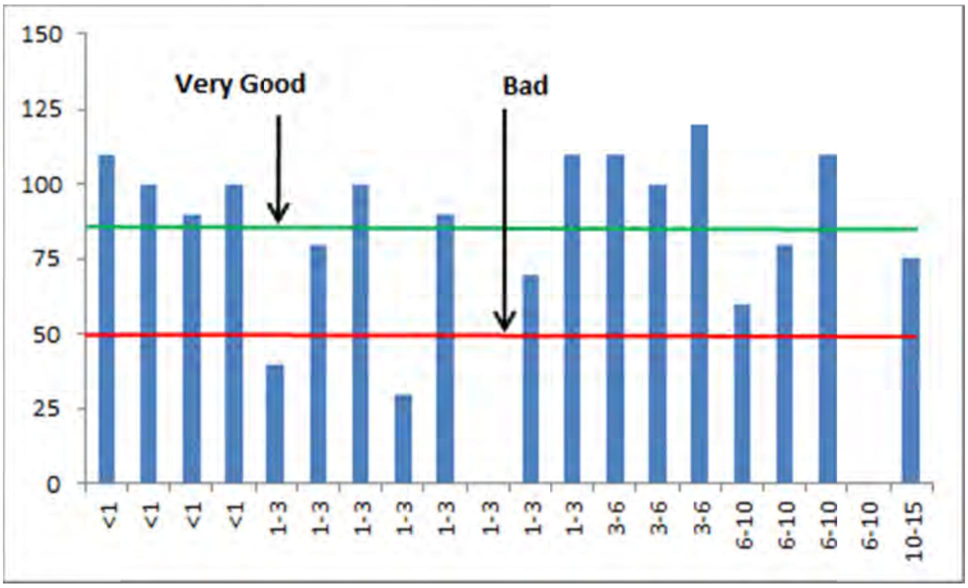

Figure 3.3. Distribution of audit scores among channel sizes in 2016

Scores in excess of 85% or 'Very Good' category (denoted by green line of Figure 3.3) were achieved in four of the five size classes of channel examined (Figure 3). The revised audit form scoring begins with a crew having a score of 100%. A crew that is fully compliant in respect of the various items from the 10 steps that are relevant at that site achieves a score of 100%. Deviation from compliance – with red, orange and yellow categories denoting reducing levels of deviation – leads to reduction of score from the 100% level. Major deviation from compliance attracts 'red' category marking of minus 70%. On the other hand, a 'bonus' scoring is also available in some categories within specific topic areas. This 'green' category of marks provided for scoring above the standard compliance level and is reflected in the scores exceeding 100% (Figure 3.3). 'Bonus' scoring was achieved by some drivers in areas such as water celery management (Item 4 – Managing vegetation), of skipping sections (Item 5) and substantial implementation of new diggings (Item 10). Four sites recorded 'Bad' audit scores (denoted by red line of Figure 3.3).

One of the sites recording a zero score was receiving a radical re-engineering of the cross-section and longitudinal profile, based on engineering survey i.e. the driver was acting under instruction. The site was scored as per a routine audit for compliance and achieved the zero score. The score reflects the negative impact of the works on the channel habitat and the degree of deviation of the work from the environmental guidance.

3.1.3 Compliance with specific elements of the 10 point Environmental Guidance

Item 1 – bank slope protection: This topic was relevant in all cases. There was a moderate level of compliance – 12 of 20 - for non-working bank and 16 of 20 on working bank slope. Deviation from compliant was in the lower level 'Yellow' category at six sites for the non-working bank. Two serious deviations ('red' category) were recorded.

Item 1 - Protecting the bank slope

Category	Non-working bank	Working bank
Compliant	12	16
Yellow	6	2
Orange	0	0
Red	2	2
Total	20	20

This is a very basic topic where high scoring should be achieved and where a higher level of compliance than that recorded in 2016 would be expected.

Item 2 - confining maintenance to channel centre / no over-digging: Apart from the single location, referred to above, where major re-engineering was being undertaken, there was a high degree of compliance (19 of 20) with Item 2. No records of significant or continuous over-digging of the channel bed were evident.

It was difficult to ascertain the extent to which staff were implementing lamprey and crayfish SOPs, at the audit sites themselves. Fresh sediments examined in audit did not show signs of either animal. Continuous emphasis on this topic of lamprey larvae and crayfish occurrence in spoil is required when foremen are examining and discussing sites and maintenance progress with their drivers. The OPW time cards do have a slot for recording evidence for either or both animal, with results to be filled in by the drivers on the time cards.

Item 3 – spoil management: Spoil management was recorded in 19 of the 20 audits and was fully compliant in all cases. This topic is difficult insofar as drivers may not have the option to dispose of the spoil OUTSIDE the channel cross-section. The preferred location of disposal from a fisheries point of view is on existing spoil lines or out on the bank full line. However, there is an option, of necessity, to permit disposal on the working bank slope. Fifteen of the audits showed disposal on the spoil line or bank top with one record of disposal on the non-working bank slope as well. Of the four observations of disposal on the working bank slope, two were inside the working bank fence line and one also had disposal to the non-working bank slope.

Item 4 - Spoil Management

Spoil management		I/s fence	non-working slope
Spoil heap/bank top	15		1
Working bank slope	4	2	1

The issue of allowing water to drain out of the bucket is seen as a benefit in possibly allowing fish and invertebrates to be washed out of spoil and back into the channel. In addition, it reduces the amount of water being drawn out onto land. Where spoil is being placed on the bank top, and more particularly, on the bank slope it is important that the drivers allow substantial tipping off of water. This can reduce or prevent sediment from flowing back down the bank slope and re-entering the channel. This feature is difficult to record in auditing as the crew commonly stops work on arrival of the audit team, out of courtesy.

Item 4 - vegetation management: Vegetation management was relevant in 16 of the 20 sites visited.

There were 11 cases involving tall reeds and flaggers and 5 cases involving water cress/celery. In some audits, both plant groups were relevant. Nine of the 11 cases involving tall reeds were operating in a compliant manner, one incurred a yellow and the red case was that where a major re-engineering of the channel was underway.

In the case of water cress, five sites were relevant. Here, a combination of skimming off the celery (3 sites) and non-excavation of the channel bed (2 sites) was expected for compliance.

Two sites involved management of grass vegetation. Both were compliant and one of these incurred a green or 'bonus' score.

Item 4 - Vegetation management

		Compliant	Yellow	Red	Green
Tall reeds	11	9	1	1	
Water cress (skimming) (not digging bed)	5	2			3
Grass vegetation	2	1			1

Item 5 – skipping sections: Skipping arises for one or several reasons in any situation and was recorded during the 2016 audits in 7 of the 20 visits. A mature tree line was identified in 4 cases of skipping. Along with this, reasons included presence of 'self-cleansing' gradient (1 case) and overhead power cables (2 cases). Skipping has been a common feature of maintenance practise for many years with several foremen, reflecting a practical approach to self-cleansing gradients and *in situ* tree and shrub cover.

Item 6 - managing trees: This item was relevant in 19 of the 20 audits carried out in 2016 – primarily in regard to avoidance of damage to trees during the closed season. The majority of crews were undertaking good work in regard to protection / care with trees encountered (13 of 19 cases). Two further crews scored 'green' bonus marks on account of exceptionally good work while two of the crews incurred 'yellow' scoring for localised shortcomings in this item.

Item 6: tree management

	Compliant	Green	Yellow	Red
6.9 - high level avoidance	13	2	2	
6.3 how cut				2
6.8 wildlife refuge		3		

2 crews attracted a 'RED' designation due to use of the machine bucket for handling the tree cover. As stated on previous occasions, this practise is unsightly and detracts from what is otherwise, generally, good quality work. There were 3 cases of driver crews using 'managed' timber material in a way that was beneficial as wildlife cover. The material was stacked in low piles along the top of the bank and prevented from falling back into the channel by placing immediately behind retained woody cover. These crews recorded 'green' bonus points for this work, as per the Audit form.

Item 7 - Managing berms: Berm management was recorded at three audit locations. One of these was compliant with the 10-step guidance while the other two were not. Of these two, one attracted an 'orange' score indicating a substantial deviation from the required approach. The third site attracted a 'red' score' indicting that the performance was completely deviating from the required practise. This was a location , referred to above, where major re-profiling of the channel was underway.

Item 8 - placing rock / replacing rock stone the channel: Three instances of this were recorded. One was compliant in returning materials dug out in maintenance while a second one achieved a 'green' score here for a high level of compliance. At the third site there was an opportunity to implement this measure but the crew was not implementing it.

Item 9 – working in gravel bed channels: There was one incidence of this Item and the performance was compliant.

Item 10 – New excavations in the channel: This topic was considered relevant in 7 of the 20 sites. Scoring was possible under three headings and in several cases more than one was being used.

Topic 10 - New excavations

	Applicable	Compliant	Green	Yellow
10.1 Digging pools etc.	6	3	1	2
10.2 Overdeepen	2	1	1	
10.3 Instream structures	0			

The most 'straightforward' measure involved overdig of the channel bed to create pool areas and re-allocation of the spoil to create shallow embryo riffles. This was being undertaken in a compliant manner on 3 of 6 relevant sites and was being performed to a high level ('green' score) in one site. A further two sites were scored as 'yellow' indicating that this strategy could have been implemented to some degree but was not being pursued.

Overdigging round the outer side of bends, creating a low-level berm and two-stage channel was being actively pursued at two locations. In one of these a high level of performance was achieved ('green' score)

4 Scientific Investigations and Monitoring

4.1 Stonyford River (C1/32/33), Boyne Catchment Fencing Experiment

The objective of this study (on-going) has been to quantify the effect of this commonly adopted stream rehabilitation methodology (Fencing) on a small channel. The rehabilitation strategy is to exclude livestock by fencing off the riparian zone, provide cattle drinks and allow the riparian and instream channel to revegetate. The key research issues under investigation are:

- The response of riparian and aquatic vegetation to fencing (2-3 years), and to habitat change in the longer term (3-5 years)
- The response of channel morphology (width, depth, sediment type) to riparian and aquatic vegetation rehabilitation
- The response of the fish community to riparian and aquatic vegetation rehabilitation (2-3 years) and to habitat change in the longer term (3-5 years)

The basic experimental design is a BACI (before, after, control, impact) style design with the target channel (Stonyford tributary (C1/32/33)) monitored for five years. This study has been published in the peer reviewed journal: Ecological Engineering.

O'Briain, R., Shephard, S. and Coghlan, B., 2017. Pioneer macrophyte species engineer fine-scale physical heterogeneity in a shallow lowland river. Ecological Engineering, 102, pp.451-458.

Link: http://doi.org/10.1016/j.ecoleng.2017.02.047

4.1.1 Introduction

We collected data on plant community structure, fish community composition, channel physical morphology, bed type characteristics and flow regimes in 5 different study plots distributed within a 1.5km non-shaded section of the Stonyford river, with varying levels of macrophyte cover. Data were collected in late July of 2013 and 2014 before vegetation removal and subsequent fencing. Subsequently, all vegetation was removed from the study reach as part of stream management works aimed improving water conveyance, a fence was then erected to exclude livestock. Additional data were collected in July 2016 to assess vegetation and morphological response and recovery.

We documented the macrophyte species that established post-removal, and their effect on descriptors of physical state within the channel. We classified plant species recorded at each sample site according to morphotype and plant traits and developed statistical models to test for relationships between macrophyte presence and re-naturalisation (defined as increasing heterogeneity) in key physical descriptors (flow velocity, depth and substrate type).

Study area

The average bed width was approximately 4m and average water depth was 0.4m. The Stonyford River is a characteristic Irish lowland river with low-moderate flow velocities (maximum recorded velocity at sample sites = 0.75 m s^{-1}), abundant macrophytes and a mixed bed load. Its fluvial patterns are typified by a meandering single-thread channel, bounded by cohesive alluvial plains. The river has been arterially drained and has also been subject to cyclical river maintenance which has helped to maintain a very homogenous physical form.

4.1.2 Results

Macrophyte frequency

Branched broad leaved emergents (BBLE) and tall linear emergents (LE), were consistently the most frequent macrophytes recorded each sample year. These morphotypes accounted for approximately 77% of all records. Species within the BBLE group consisted predominantly of *Nasturtium officinale* L., *Apium nodiflorum* L. and *Berula erecta* L. and were widely distributed within the wetted channel. Tall linear emergents (LE) were accounted for by *Phalaris arundinacea* L. almost exclusively, which was limited to the wetted margins. The distribution and change in plant morphotypes in site 3 is given in figure 4.1.

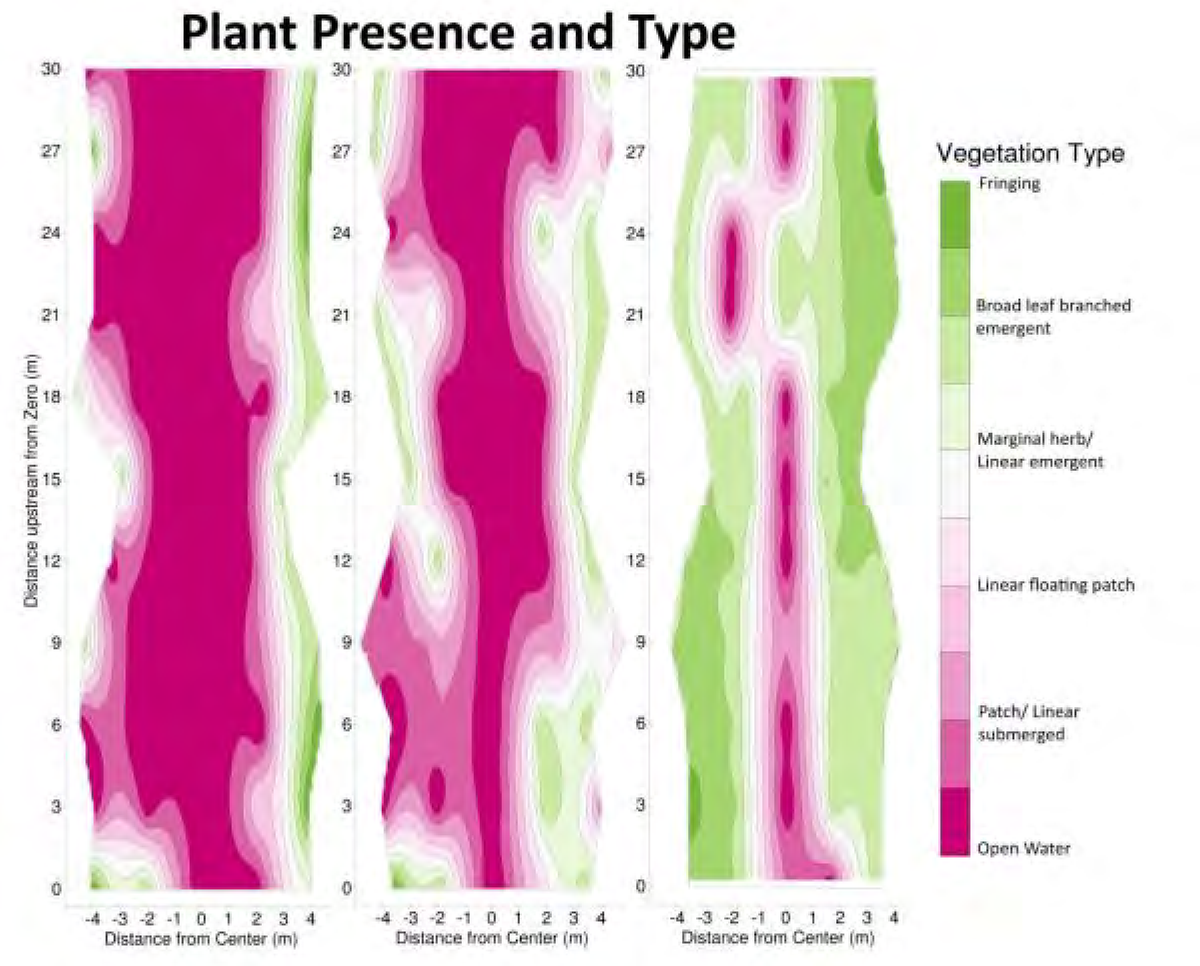

Figure 4.1. Isolines estimated around point values of the vegetation type index (morphotypes) for one of the studied sites, illustrating changes in the extent and type of macrophyte cover in 2013, 2014 and 2016 (from left to right).

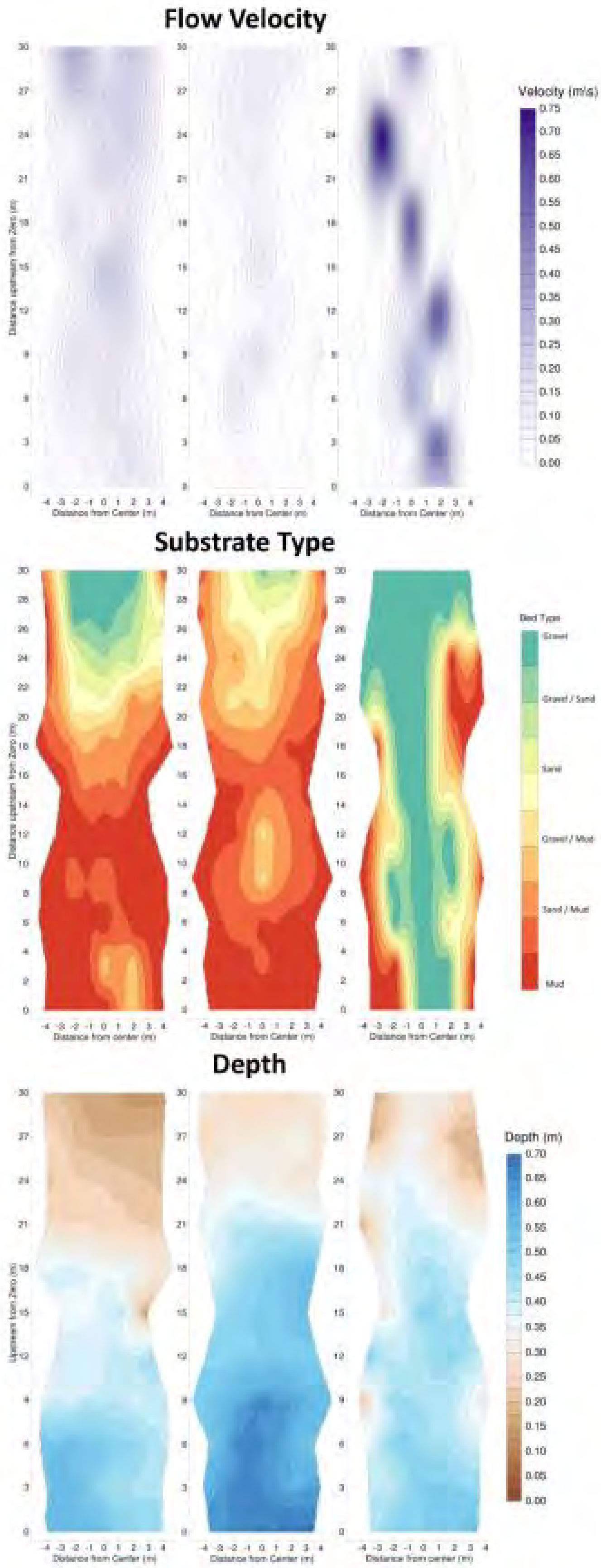

Figure 4.2. Isoline maps interpolated around point observations of flow velocity, substrate type and depth, observed during 2013, 2014 and 2016 (left to right) at the same site as is shown for macrophyte cover and type in figure. 4.1.

Flow velocity, depth and substrate type

Statistical models indicated some close interactions among physical variables *(flow, bed type and depth)*, and also between physical variables *(flow, bed type and depth)* and plant presence. The results suggest that increasing plant presence has a direct positive effect on heterogeneity in stream depth and flow velocity, with subsequent indirect velocity-mediated effects on substrate, i.e., greater heterogeneity in velocity leads to a shift from fine material to gravel and cobble substrate. This process is evident in digital terrain maps that illustrate physical descriptor responses to varying macrophyte cover in different years (Figures 4.1 and 4.2).

Fish community structure

714 fish were captured measured and returned in the 5 survey sites over the 3 years. Brown trout (*Salmo* trutta L.) was the most abundant species, followed by roach (*Rutilus rutilus* L.), three-spined stickleback (*Gasterosteus aculeatus* L.), salmon (*Salmo salar* L.), Lamprey *sp.* (*Lampetra Sp.* L.), European eel (*Anguilla anguilla* L.), Perch (*Perca fluviatilis* L.), Crayfish (*Austropotamobius pallipes* Lereboullet.) and Pike (*Esox lucius* L.). Mean minimum density (no/m^2) with 95% confidence intervals for the four most abundant species is given in figure 4.3. There has been significant changes (G = 116.787, DF = 6, P = <0.05) in the frequency of the four most abundant species over the 3 sampling years. This is due to an increase in brown trout and a reduction in lamprey *Sp.* and roach numbers.

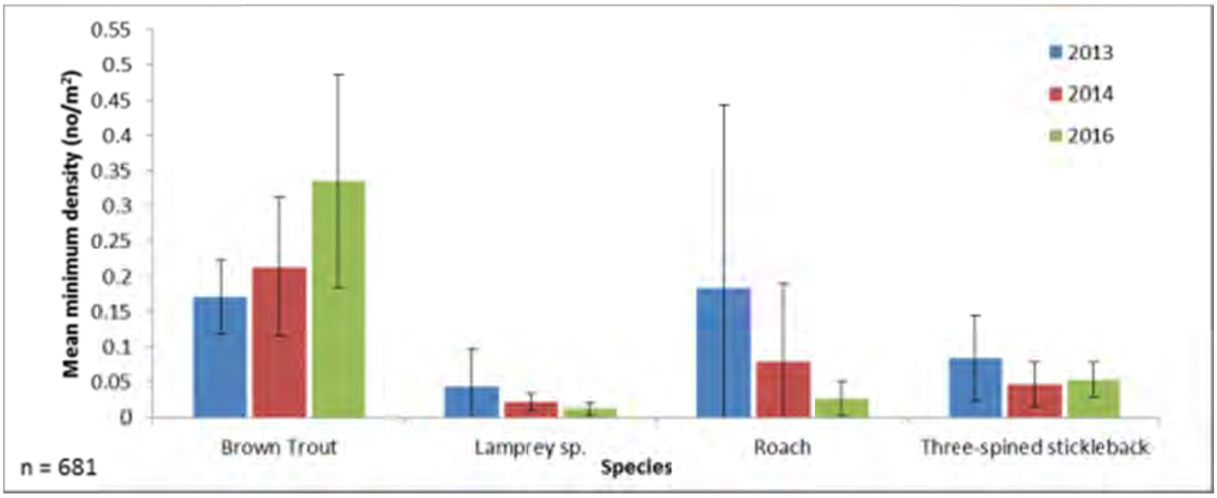

Figure 4.3. Mean minimum density (no/m^2) with 95% confidence intervals of the four most abundant fish species in the Stonyford River experimental sites 2013, 2014 and 2016

4.1.3 Discussion

Recovery of channelized rivers is associated with increasing structural and hydraulic diversity. Our results suggest that heterogeneity in flow and depth are directly mediated by macrophyte establishment, with subsequent effects on substrate composition. Recovery toward a more natural hydraulic (flow and depth) regime probably occurs because establishing macrophytes block and deflect flow, leading to changes in fine-scale velocities. Associated recovery in substrate likely follows macrophyte-driven flow manipulation that encourages the deposition of fine sediment, particularly on the margins, and the mobilisation of fine sediment in the mid-channel through flow constriction and accelerated velocities that 'wash' gravels.

Early analysis of the fish community composition indicates that increased structural and hydraulic diversity has led to increased brown trout habitat and therefore increased brown trout numbers. Increased brown trout recruitment could have been facilitated with the availability of fresh gravels exposed through flow constriction and accelerated velocities and increased macrophyte cover may be functioning as refuge habitat and reducing population mortality.

Bio-geomorphic feedbacks play an important role in both macrophyte development and channel morphology. Areas subject to scour have lower sediment/nutrient availability and higher flow velocities, creating less favourable conditions for macrophyte growth but more favourable for 'clean' gravel aggradation or the generation of depth diversity through obstruction and scour. In contrast, areas of deposition create shallow areas that collect seed and organic material, creating preferable conditions for plant growth and potential for successional change.

It is proposed that this set of sites will be monitored in the medium to long-term to provide further insights on the impact of fencing and of duration of intervals between maintenance events on the instream and riparian plant and fish life and of the physical dimensions of the channel.

4.2 Abbey River Capital Works Monitoring

4.2.1 Introduction

The Abbey River, also referred to as the Two Mile water and Behy Rivers, drains an area of *circa* 42.1km^2, discharging into the Erne estuary west of Ballyshannon. There are 53.44 km of river channel in the Abbey catchment with the OPW arterial drainage scheme encompassing 33.5km (Figure 4.4). There are 34 lakes in the Abbey River Catchment, 30 are less than 10ha, the four largest are Roshin Lough (13.8ha), Lough Lee (15.1), Lough Unshin (27.2ha) and Lough Golagh (60.4ha).

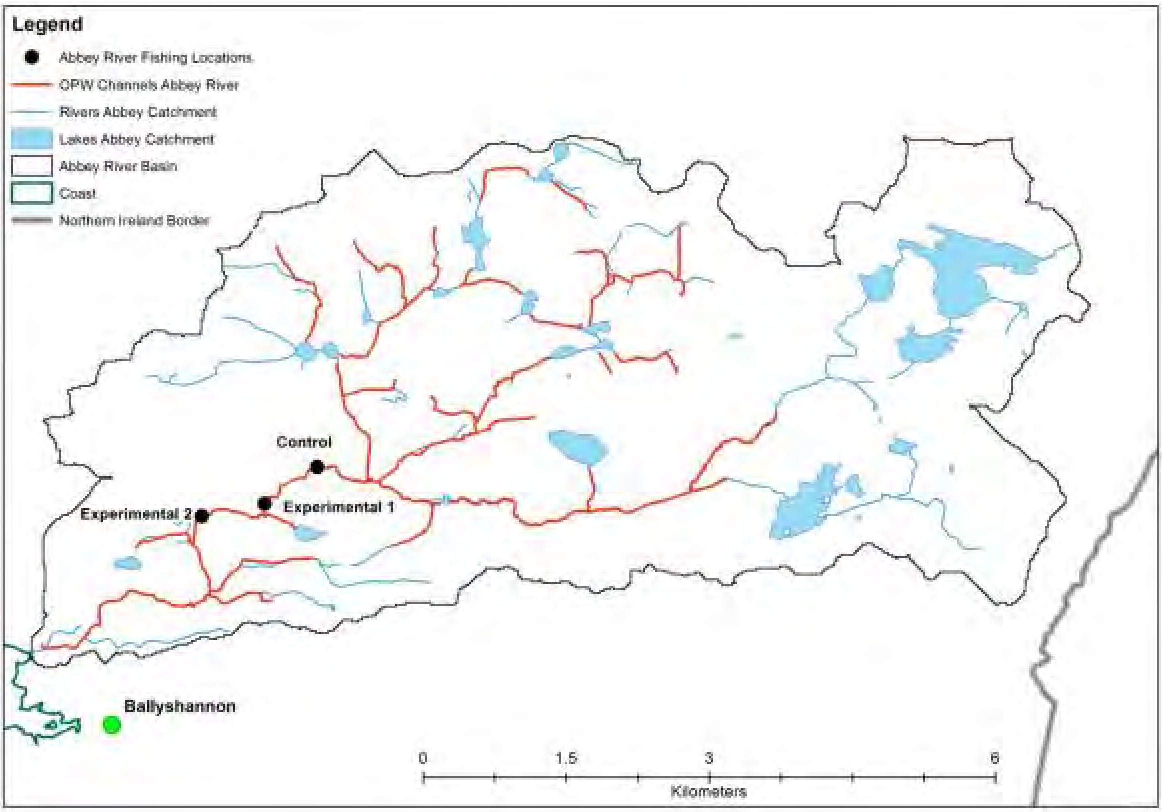

Figure 4.4. Abbey River catchment outlining locations of Capital works (Experimental sites) and control site.

The Abbey River was selected for a Capital works programme in 2014. This catchment has good gradient in sections and predominately satisfactory water quality. It has, typically, a gravel cobble bed, but post arterial drainage it is lacking in natural features and gravel shoals for spawning salmonids.

The basic experimental design is a BACI (before, after, control, impact) style with the target channel monitored for two years pre works, immediately post works and for a number of years strategically post works. This update is reporting 1 years post capital works. Three sites have been monitored, a control site where no works have been done, upstream of the experimental sites and two experimental sties were works were undertaken. Experimental site 1 comprised the construction of paired deflectors, pools and gravel shoals; experimental site 2 involved the construction of a series of alternating deflectors. Unfortunately experimental site 2 was only completed in 2016 and therefore was not fished in that year.

4.2.2 Experimental site 1

Downstream of the bridge at Parkhill two sets of paired deflector, pool and spawning shoal combinations were constructed (figure 4.5). Pre-works this section lacked water depth in summer low flows and had a bed type dominated by larger cobble/boulders. Works through this section have changed the flow pattern and habitat diversity by locally increasing water depth through the section. The bed material available for salmonid spawning has been augmented with the addition of spawning gravels downstream of the excavated pool areas.

Figure 4.5. Constructed in 2015 Experimental Site 1 consists of two paired deflectors with pools and gravel shoals (Top Pre works: 2014, Bottom Post works: 2016).

4.2.3 Experimental site 2

Experimental site 2, a long straight section of medium to low gradient, has a series of low stone alternating deflectors (5) constructed through its length (figure 4.6). Deflectors are increasing instream habitat diversity by creating flow heterogeneity with depositional and erosional areas in an otherwise uniform channel.

Figure 4.6. Constructed in 2016 experimental site 2 consists of a series of alternating deflectors (Top Pre works: 2014, Bottom immediately Post works: 2016) (note: OPW machine still on site)

4.2.4 Fish population response to capital works

Across all sites, 0+ brown trout density (no/m^2) remained constant over the three year sampling period (2014 to 2016). ≥1+ trout density also remained stable in the control and experimental site 2 with a small increase in ≥1+ trout density post works in experimental site 1 (Figure 4.7).

Salmon fry densities in both the experimental and control sites show fluctuations both pre and post capital works. Salmon par densities remained stable both in the control and experimental site one. The slight increase observed in ≥1+ trout in experimental site one is probably due to the increase in site depth due to pool construction, average depth increasing from 0.21m to 0.38m post works.

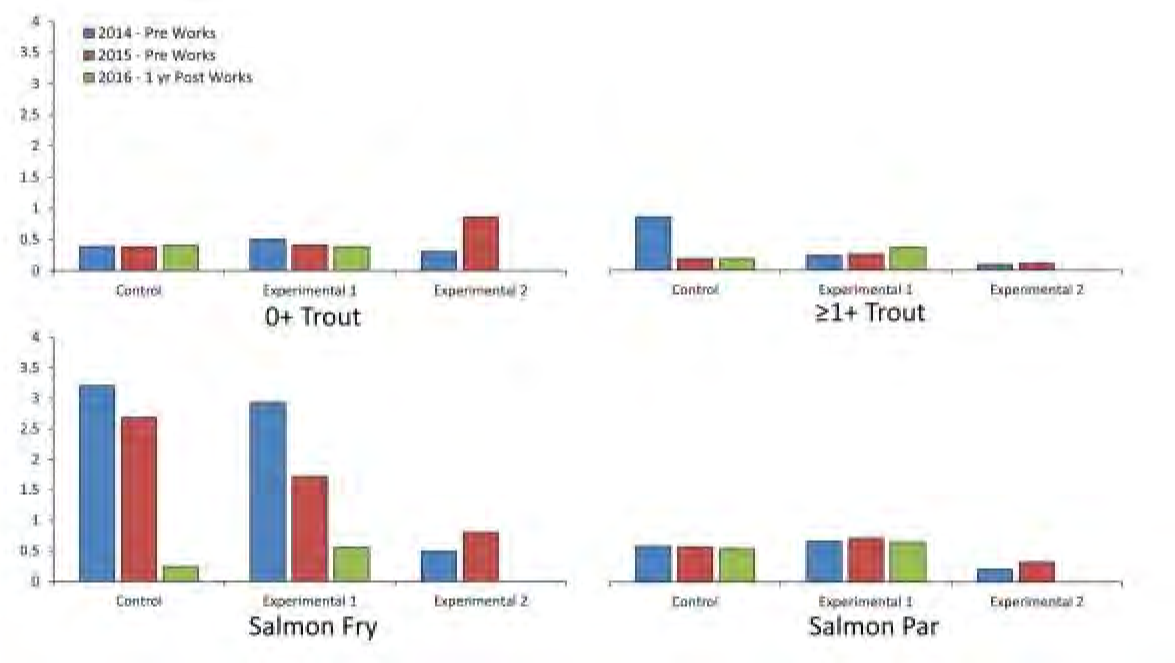

Figure 4.7. Trout and Salmon life stage densities (no/m^2) pre and post work on the Abbey River experimental and control sites 2014 to 2016.

A statistical examination of the fish community composition from experimental site 1 and the control site (figure 4.8) over the 3 years was undertaken (G-test). This suggested that there were significant changes in the fish community composition between each sampling year in experimental 1 (2014 V 2015: G (adj) 10.27, $p = 0.016$, 2015 V 2016: G (adj) 47.33, $p < 0.001$). Fluctuations in the abundance of salmon life stages in the fish community are driving these differences. There was proportionally more >1+ brown trout and proportionally less salmon fry in the fish community in experimental site 1 post capital enhancement works. In the control site there was no statistical difference in the frequency of the species and their life stages between 2014 and 2015 (G (adj) 0.378, p = 0.945), however 2015 and 2016 were statistically different (G (adj) 17.35, *p < 0.001*). This was due to a lower proportion of salmon fry in the control site in 2016.

Changes observed in both the fish community structure and abundance at both the control site and experimental 1 appears to be driven by salmon fry recruitment. Both figure 2.4 and 2.5 show a decline in salmon fry both in terms of density (no/m^2) and in there percentage community composition from 2014 to 2016.

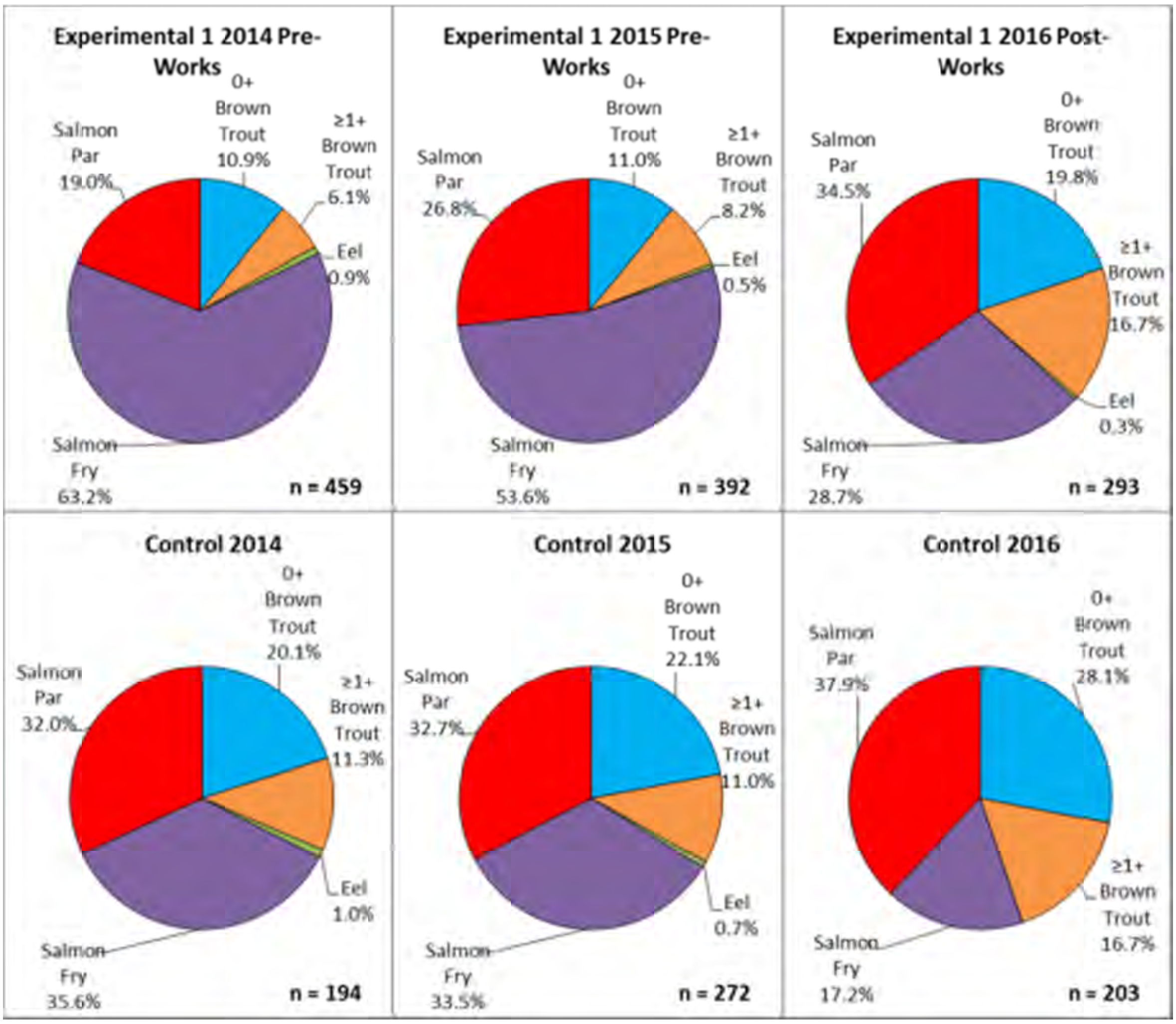

Figure 4.8. Fish community composition at experimental site one and control site sampled from 2014 to 2016.

4.3 Bonet Catchment Wide Survey: a comprehensive series of Fish and habitat studies

4.3.1 Introduction

The Bonet catchment was surveyed between the 30th August and the 9th of September 2016. In total 27 sites were sampled in order to determine the density, distribution and population structure of the fish species in the Bonet catchment (Figure 4.9) and the hydromorphological and water quality pressures which could be affecting them.

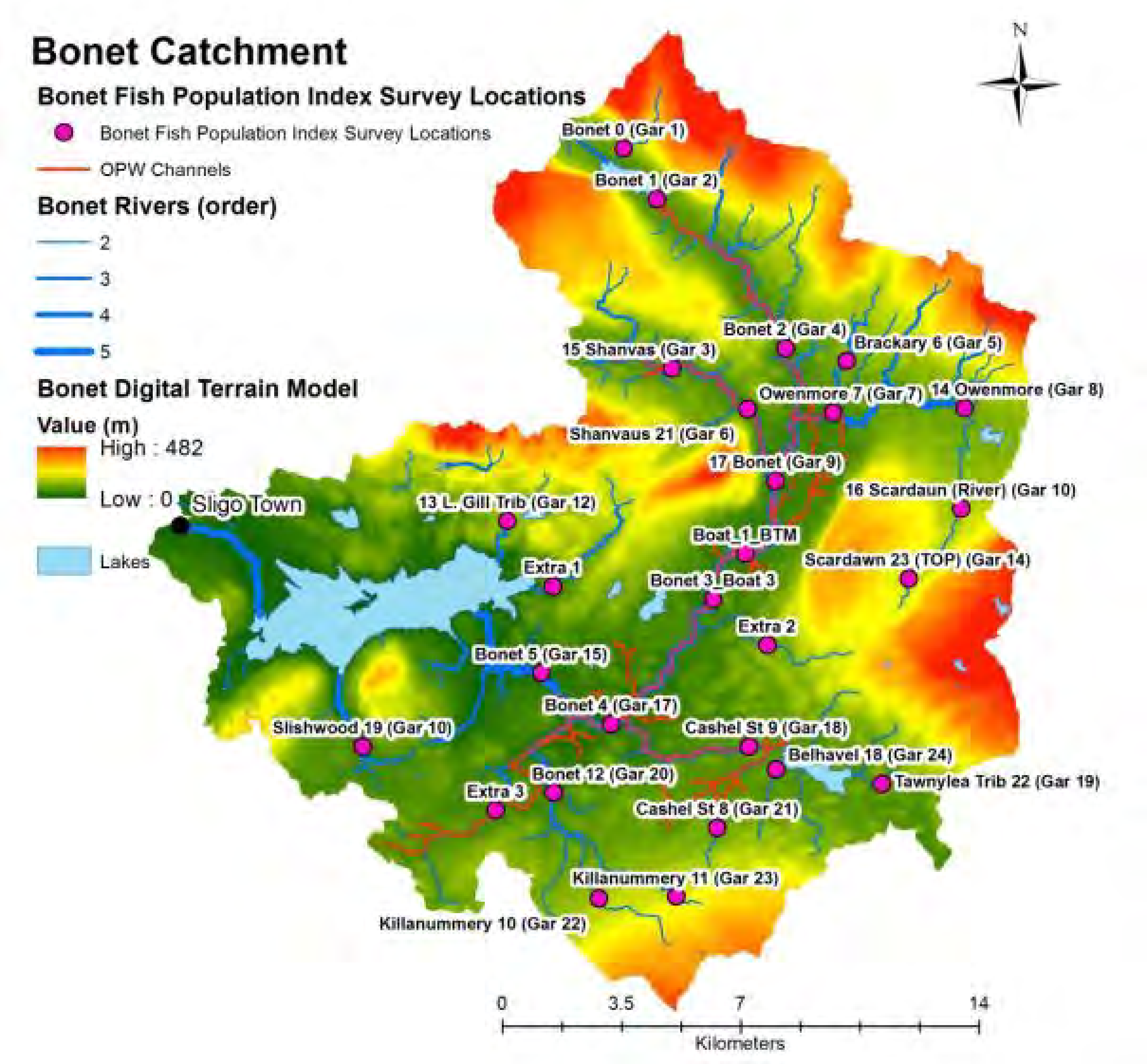

Figure 4.9. Elevation map of the Bonet Catchment with FPI survey locations

The Bonet River rises north of Manorhamilton, Co. Leitrim, at Glenade Lake. It flows south, past Manorhamilton, and then turns in a westerly direction, past Dromahair, and into the eastern end of Lough Gill. The Bonet catchment drains an area of approximately 405 km2. The Bonet has a number of larger tributaries, the Owenmore River, the Shanvaus River, the Cashel Stream and the Killanummery Stream. A number of smaller rivers also discharge into Lough Gill - the Stream at Fivemilebourne, the Newtown Manor Stream and the stream discharging at Slishwood. Lough Gill discharges through the Garavogue River into the sea at Sligo Bay, flowing through Sligo town.

The catchment consists of a series of glacial U-shaped valleys between flat topped mountains. The geology is limestone overlain with millstone grits, with shales and sandstones on the upper mountain slopes. The river is fast flowing in its upper sections with confining valleys, becoming meandering and sluggish as the valley floors become less confining.

The Bonet catchment drainage scheme was conducted by the Office of Public Works from 1982 to 1989. Channels were deepened and widened and the spoil buried in the riverbank on which the excavating machine was operating, affecting approximately 30% of the catchments waterbody's. The scheme included the main Bonet channel from Glenade Lough to Dromahair, the lower section of the Killanummery Stream, the Shanvas River and the Cashel Stream (Figure 4.9). Sections of the river subjected to arterial drainage can be characterised by steep-sided high banks, disconnection from the surrounding floodplain and a simplified long section. Post works (1989) funds were provided by the OPW for river rehabilitation, works included replacement of spawning beds, and the creation of new beds, the placement of weirs and boulders, tree planting and improvement of access to anglers. Drainage maintenance may also affect instream sediment dynamics effecting larval lamprey populations. There is a significant bedrock outcrop at the Village of Dromahair. At this point the river falls approximately 9m over a series of bedrock outcroppings, creating a sequence of waterfalls (Figure 4.9, Bonet 5 (Gar 15)). This feature poses a significant natural barrier to anadromous and catadromous fish species. The river is slow flowing from downstream of Dromahair to its discharge into Drumcliff Bay.

The Bonet Catchment encompasses 3 SAC's, Lough Gill (001976), Glenade Lough (001919) and Cummeen Strand/Drumcliff Bay (Sligo Bay) (000627).

These SAC's are designated for a number of habitat types and specie. The aquatic habitats and species include:

- Natural Eutrophic Lakes
- Estuaries
- Mudflats and sandflats not covered by seawater at low tide
- *Austropotamobius pallipes* (Whiteclawed Crayfish)
- *Petromyzon marinus* (Sea Lamprey)
- *Lampetra planeri* (Brook Lamprey)
- *Lampetra fluviatilis* (River Lamprey)
- *Salmo salar* (Atlantic Salmon)
- *Lutra lutra* (Otter)

- *Phoca vitulina* (Common Seal)

As all species of lamprey are protected under the Habitats Directvie it is imperative that IFI have knowledge of trends in populations of all three species across all life stages within relevant SACs.

In conjunction with the FPI survey, hydromorphology (River Hydromorphology Assessment Technique (RHAT)), water quality (Small Stream Risk Assessment Score (SSRS)) and abundances of larval lamprey were also assessed.

4.3.2 Bonet Fish Population Index (FPI) study

In total, 21 bank and 3 boat based electrofishing sites were fished. In conjunction with electrofishing, invertebrate (Small Stream Risk Assessment Score, SSRS), and hydromorphology (River Hydromorphology Assessment Technique, RHAT) surveys were carried out at each site.

1536 fish were captured, measured and returned in the 2016 Bonet FPI Survey. Brown trout was the most abundant species, followed by salmon, three-spined stickleback, minnow, stone loach, perch, European eel, bream, Lamprey *sp.*, roach, and Pike (Figure 4.10).

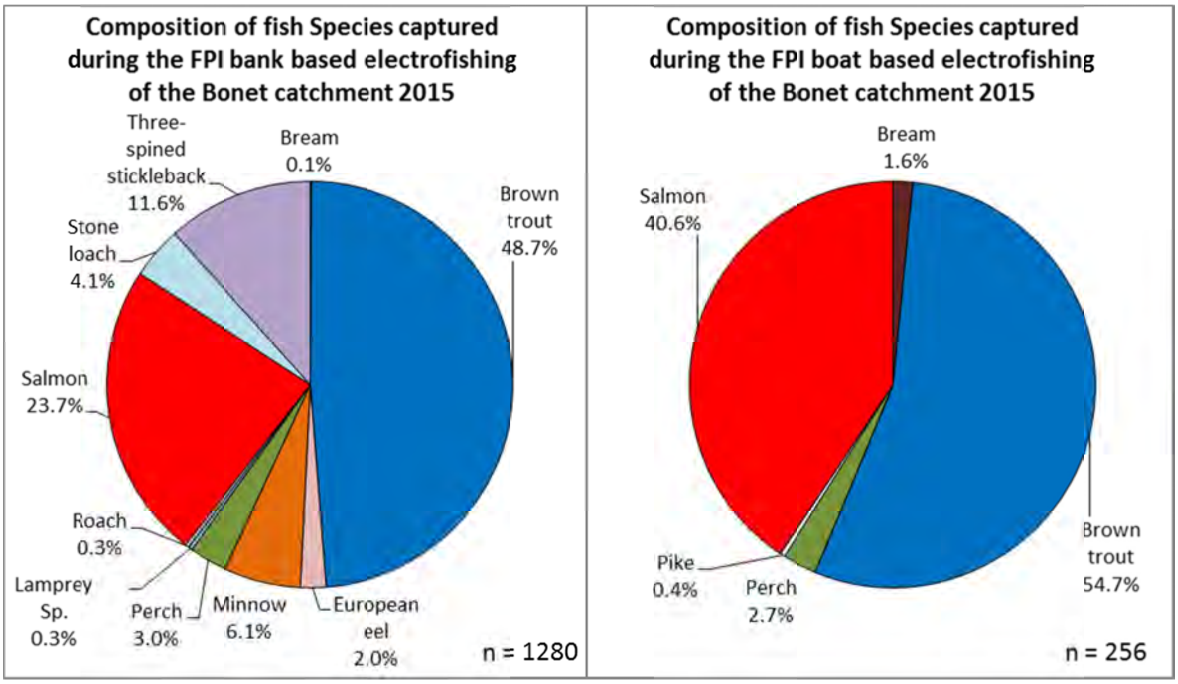

Figure 4.10. Composition of fish species captured in the Bonet Catchment FPI survey using boat and bank electrofishing equipment.

The salmonid stocks in the mid to lower reaches of the Bonet River represents a valuable angling resource. Approximately 18% of the brown trout captured were ≥28cm at Daiseys Ford (site:

Boat_1) along with good numbers of adult salmon, the largest being over 1m. The discharge and channel shape of the Bonet river downstream of Dromahair meant it was impossible to electrofish effectivley with the standard FPI surveying gear. Only three large channel sites were assesed using boat electrofishing gear as floods hampered surveying.

The two salmon life stages – juvenile and adult - can be seen in figure 4.11. Fish under 20 centimetres are salmon fry and parr, the freshwater component of the salmon life cycle. The salmon >20cm are adults which have returned from feeding at sea to spawn. These adult salmon were captured upstream of Dromahair at Daiseys Ford (Boat_1). Good salmon fry numbers of were found on the main Bonet channel (around Manorhamilton), the Shanvas river and the Owenmore River. The higest salmon fry density (69 fry/10min) was detected on the Slishwood Stream flowing directly into Lough Gill (Gar 10, figure 4.9).

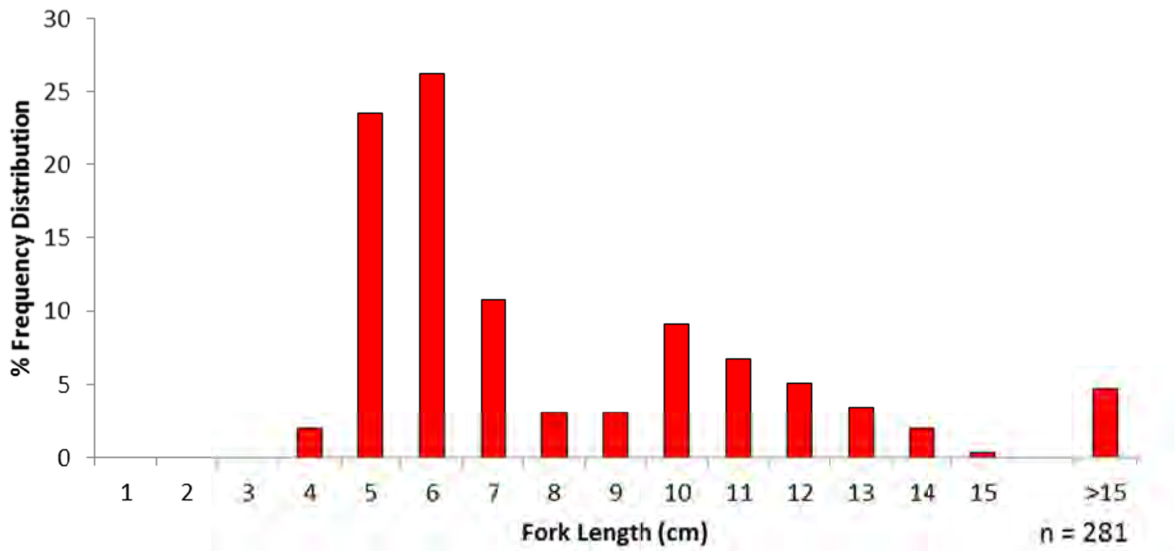

Figure 4.11. Length Frequency distribution of salmon fry (4-8cm), parr (9-15 cm) and adults (>15cm) in the Bonet catchments FPI survey 2016.

Thirty one crayfish were captured in six sites the 2016 FPI Survey (Figure 4.12). Crayfish presence in the Shanvas, Bonnet, lower Killanummurry and Owenmore rivers would suggest that they are present in most of the Bonnet system. However they may be absent from the upper Killanummurry and the Belhavel systems due to impassable natural barriers.

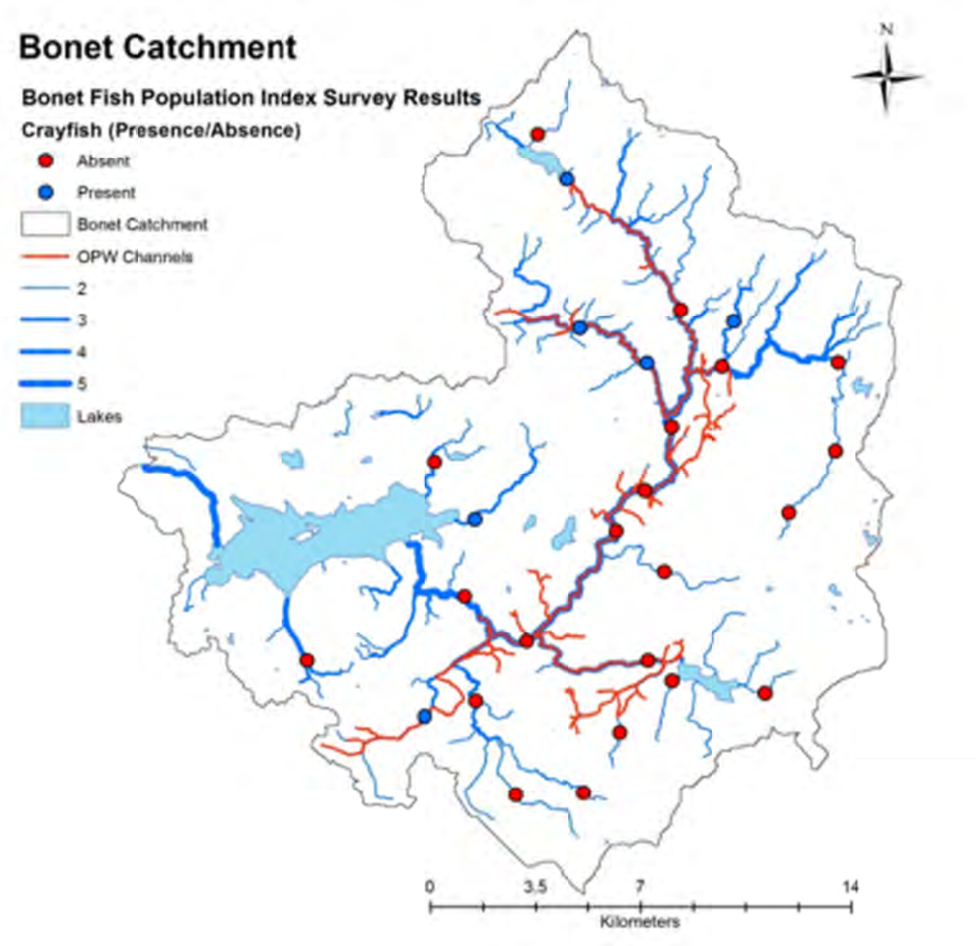

Figure 4.12. Presence / Absence of crayfish in the Bonnet Catchment detected in the FPI Survey 2016

4.3.3 Fish Ecological Quality Ratio in the Bonet Catchment

The Water Framework Directive and its transposing legislation require an evaluation of eco-system quality in rivers, lakes and transitional waters, based on a variety of 'quality elements', including fish. To be WFD Compliant three key attributes of the fish: community species —composition, abundance and age structure —must be included in the scheme for freshwater fish classification. The classification is based on an evaluation of current status of the fish community relative to the value of it reference condition—the ecological quality ratio (EQR). The ratio is expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero. Five class boundaries are defined along this range corresponding with the five ecological status classes of High, Good, Moderate, Poor and Bad. Fish EQR's were calculated for the fished sites (24) in the 2016 FPI survey. 13 were High status, 1 was of Good Status, 6 Moderate Status, 3 had Poor status and 1 had Bad Status (Figure 4.13). Therefore 58% of the sites are in satisfactory condition for the WFD, with 42% being in an unsatisfactory condition.

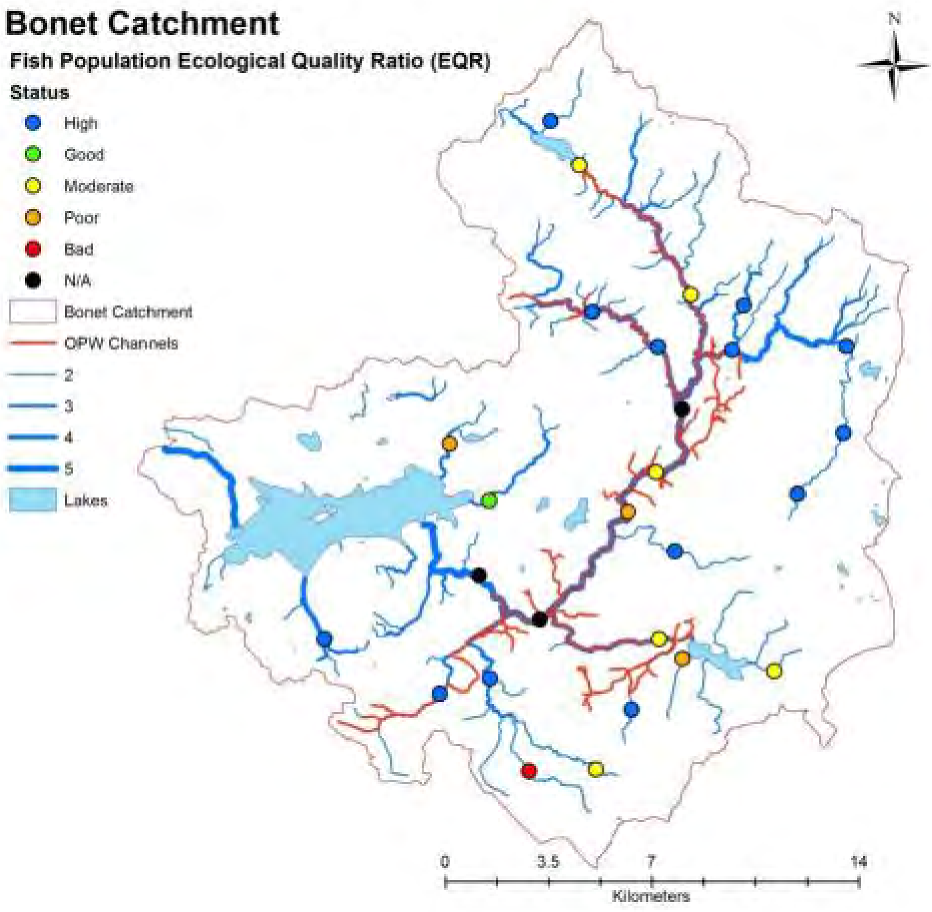

Figure 4.13. Fish population Ecological Quality Ratio (EQR) calculated for the Bonnet Catchment from the 2016 FPI Survey.

4.3.4 Lamprey Survey

This survey used the outline of the 2009 larval lamprey study on the Bonet reported in the National Programme: Habitats Directive and Red Data Book Fish species 2009. The number of sites chosen was based on the area of the sub catchment, extra sites were added to sample some larger tributaries. Generally one site was sampled per 25 square kilometres in order to give an even distribution of sites across the catchment. Sites surveyed in 2016 were in a similar location to 2009.

The distribution of larval lamprey in 2016 was closely related to the results of the 2009 survey. Larval lamprey were again detected downstream of Gortgarrigan Bridge on the Bonet River and in the Belhaval Lake river complex (Table 4.1 and Figure 4.9). Larval lampreys were detected for the first time in the Slishwood Stream, a small tributary of Lough Gill, a single young of the year (YOY) ammocoete being captured. Mean ammocoete densities are slightly lower in the 2016 survey. This does not reflect an overall decrease in larval lamprey numbers across the catchment, two large density values recorded in 2009 (12 and 11 Fish/m^2) inflating the mean density numbers of 2009 (Table 4.1. and Figure 4.9).

Table 4.1. Comparison of density and ammocoete population structure from the Garavogue – Bonet Catchment surveyed in 2009 and 2016.

	No. Sites	No Suitable Habitat	No. positive Sites	Max. Density (Fish/m^2)	Min. Density (Fish/m^2)	Mean Density (Fish/m^2)	Max. Length (mm)	Min. Length (mm)
Bonet (405km^2) 2009	24	8	6	12	1	1.5	142	28
Bonet (405km^2) 2016	23	8	7	6	1	1.7	104	21

The length frequency distribution of the lamprey ammocoete population in the Garavogue – Bonet Catchment is broadly similar between 2009 and 2016 (Figure 4.14). The 2016 survey detected an increase in YOY ammocoetes at a number of survey locations. In the 2009 survey abundant year classes were observed in the 50-60mm and >100mm size ranges. Ammocoetes were present in 30% of the sampling sites in 2016. This reflects the fluvial geomorphology of the Garavogue – Bonet Catchment which is predominantly a mid to high energy system. This is reflected in the number of sites where no suitable habitat was present (35%). Larval lampreys require fine deposited material which is unlikely to be found in mid to high energy channels.

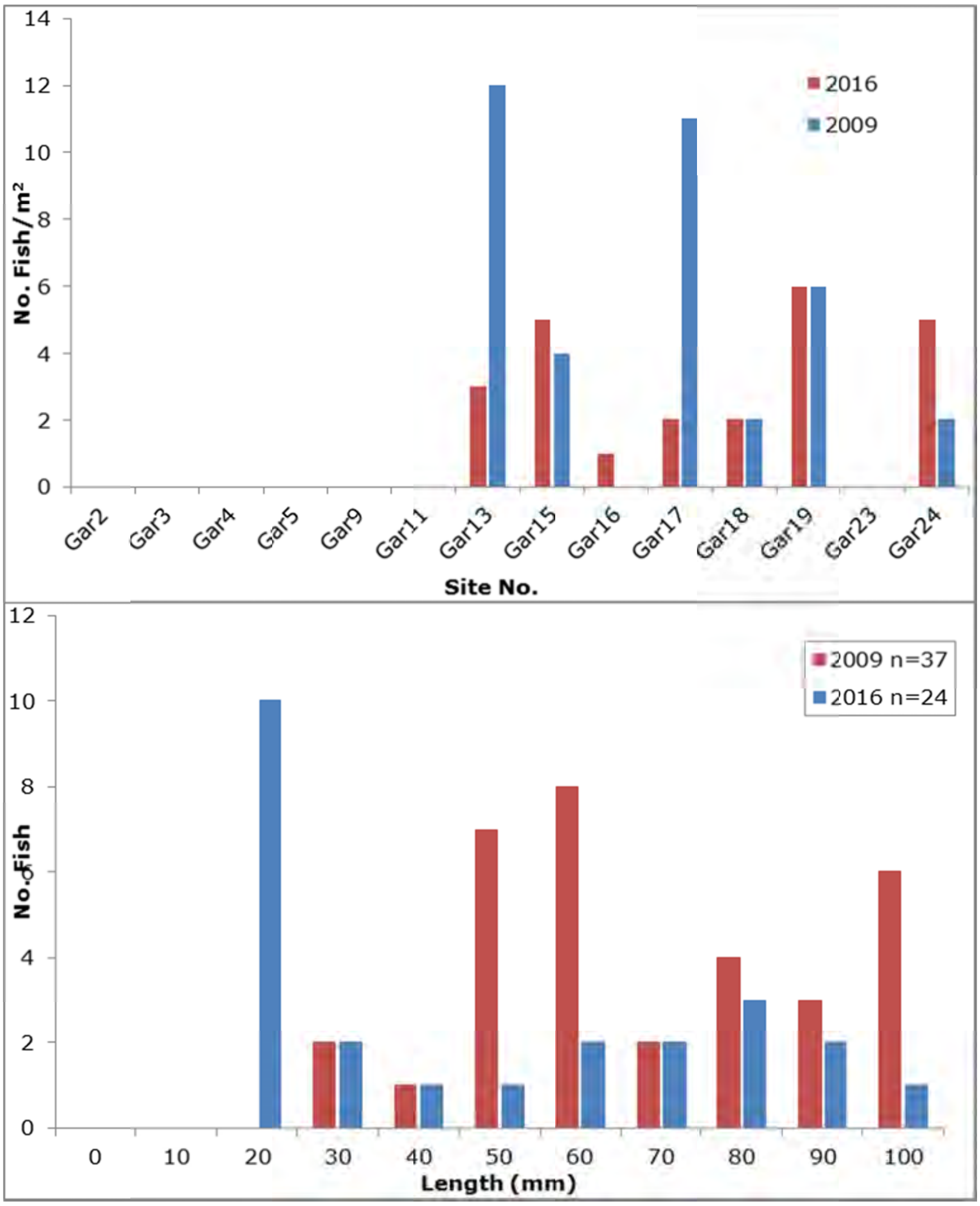

Figure 4.14. Comparison of density (top) and length frequency population structure (bottom) of the ammocoete population surveyed from the Garavogue – Bonet Catchment in 2009 and 2016.

4.3.5 Water Quality – Small Streams Risk Assessment

95% of the Water quality as sampled by the Envriomental protection agency (EPA) in the Bonet Catchment was satisfactory (WFD Status: high/ good). However, the Tullynascreen stream (Killanummurry (Gar22)) a tributary of the Killanummery River was identified by the EPA as having unsatisfactory water quality in 2015 (WFD Status: Moderate). These results are mirrored in the small stream risk assessment scores undertaken in conjunction with the FPI survey (Figure 4.15). Two sites were identified as “at risk” from water pollution L. Gill Trib (Gar 12) and Belhalvel 18

(Figure 4.15). The L. Gill Trib (Gar 12) site is an ephemeral stream which dries natural periodically, due to the underlying karst geology. Belhalvel 18 suffers from a source of nutrient enrichment. The Tullynascreen stream (Killanummurry (Gar22)) was identified as "intermediate stream may be at risk" using the SSRS.

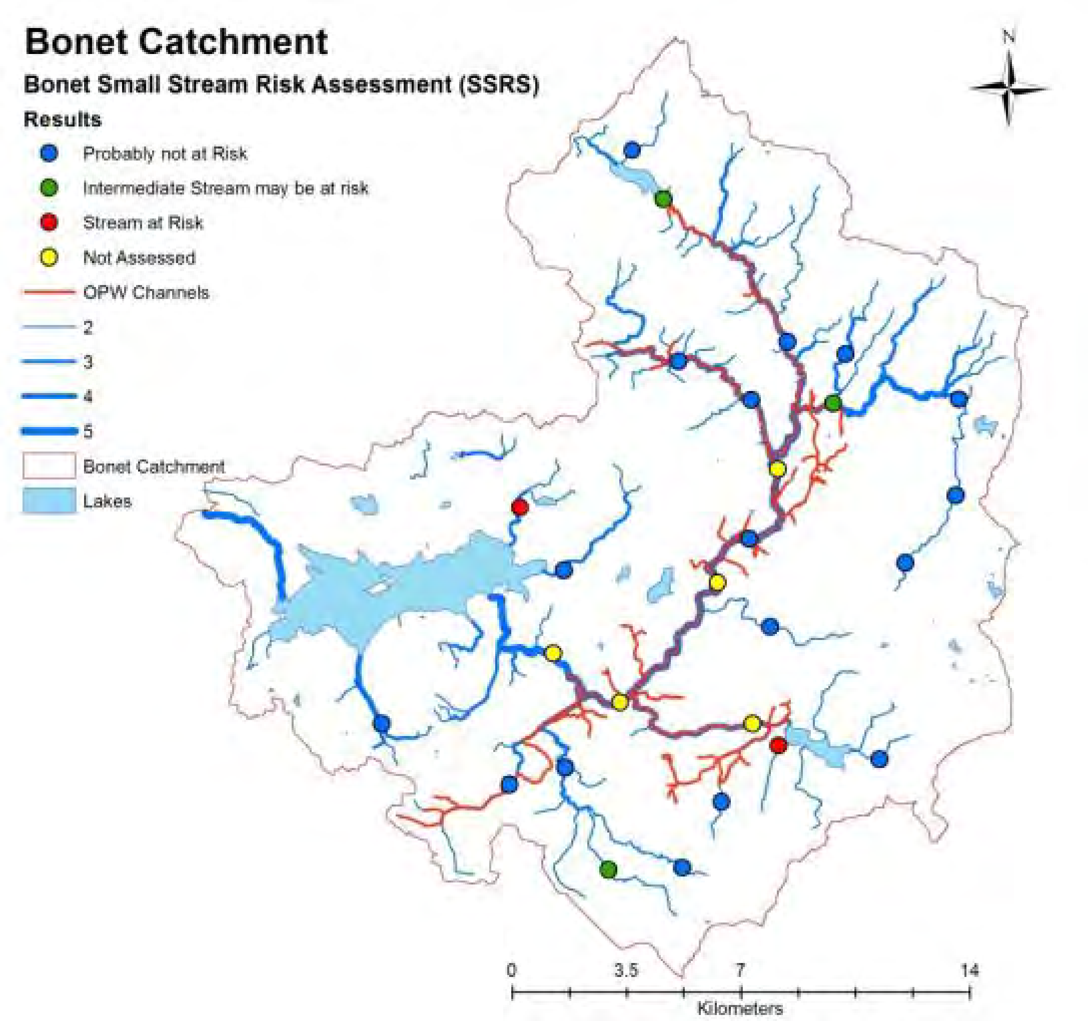

Figure 4.15. Results of the small stream risk assessment score (SSRS) for the Bonet catchment, August-September 2016.

4.3.6 River Hydromorphological Assessment Technique (RHAT)

'Hydromorphology' describes the interactions, arrangement and variability of geomorphology and hydrology of a river system in space and time or more simply put, hydromorphology is the physical habitat of a river constituted by the physical form (abiotic and biotic) and flow of the river. Key elements include the flow (sediment regimes; channel and floodplain dimensions, topography and substratum; continuity and connectivity (longitudinal, lateral, vertical and temporal); hydrological and geomorphological processes (e.g. sediment transport) and the spatiotemporal arrangement of the hydromorphological components. Other anthropogenic features such as bank protection works, artificial barriers (weirs, dams) and modifications to processes (gravel traps) are also included.

As a “supporting element” Ireland must report directly to Europe on the hydromorphological quality of Irish Rivers. The River Hydromorphological Assessment Technique (RHAT) a tool developed specifically for WFD is the Irish reporting method for Hydromorphology. The RHAT is based on the Environment Agency (EA) River Habitat Survey (RHS) and the US Environmental Protection Agency Rapid Bio-Assessment Protocols. The RHAT is designed to characterise and assess the physical structure of river channels. In short the RHAT will detect degraded hydromorphology.

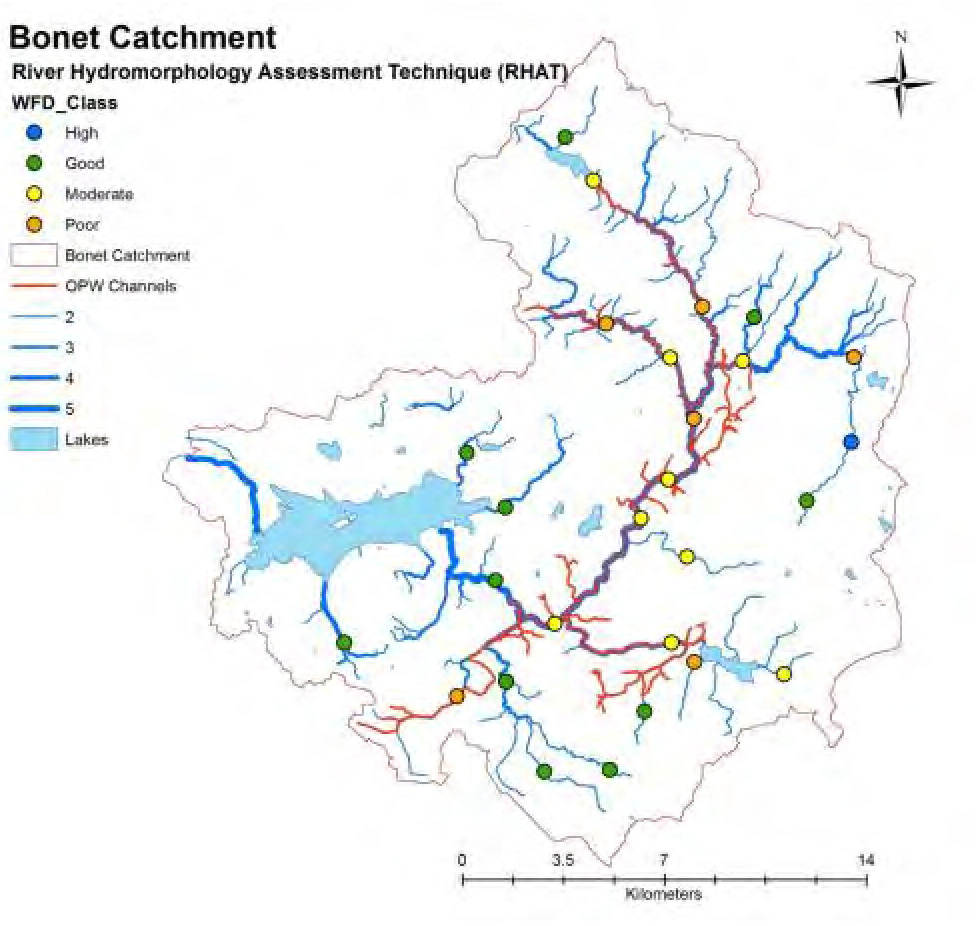

Figure 4.16. River Hydromorphological Assessment Technique (RHAT) status calculated for the Bonnet Catchment from the 2016 FPI Survey.

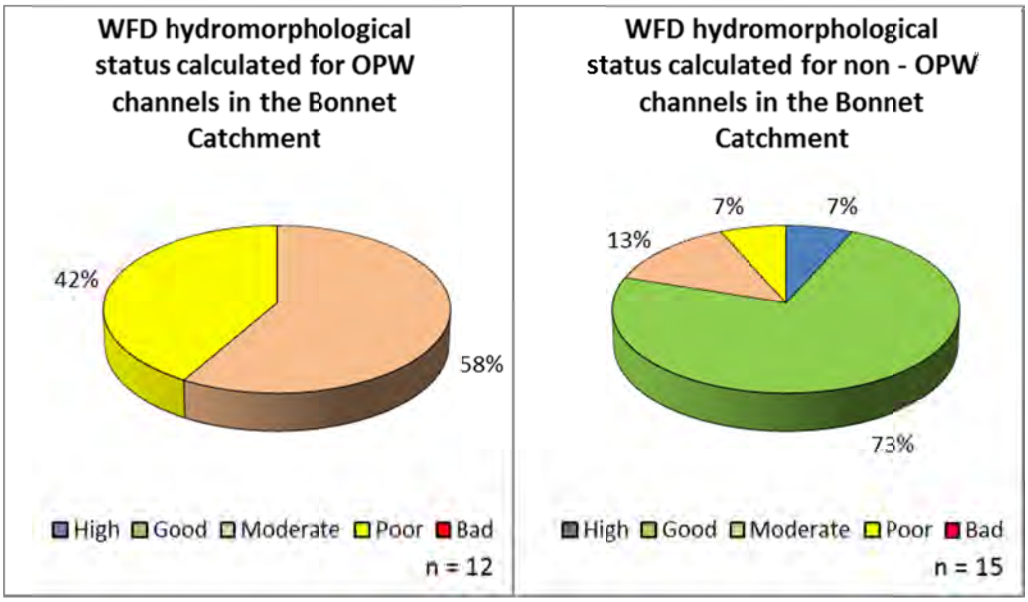

Figure 4.17. Water Framework Directive (WFD) hydromorphological status calculated for OPW and non-OPW channels in the Bonet Catchment recorded during the 2016 FPI survey.

RHAT results from the 2016 Bonet FPI survey indicate that 12 out of the 27 surveyed sites are in satisfactory hydrological condition for the WFD (Figure 4.16). Separating OPW drained sites and undrained channels (figure 4.17) it is apparent that drainage is a contributing factor for channels to be in an unsatisfactory hydromorphological condition. A statistical comparison (Mann-Whitney U test) between OPW and Non-OPW channels of the 7 components which together are used to calculate the RHAT score (Figure 4.18) indicates that for each of these components non-OPW channels score statistically higher ($P < 0.001$).

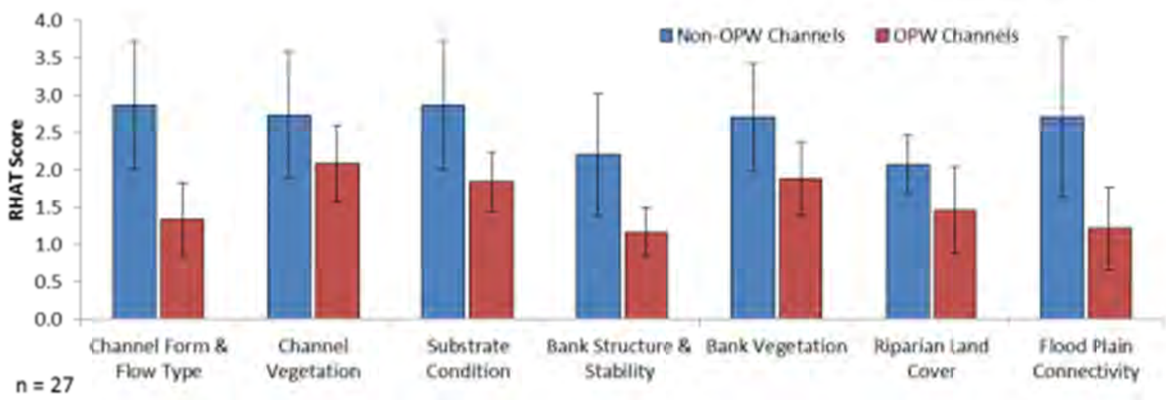

Figure 4.18. Mean and Standard deviation of the 7 RHAT components which comprised a WFD status score comparing OPW (n=12) and Non-OPW (n=15) channels in the Bonet Catchment, sampled during the 2016 FPI survey.

Investigating the 7 RHAT components the most significant differences between OPW and Non-OPW channels were observed in the categories, Channel Form & Flow Type, Flood Plain Connectivity, Substrate Condition and Bank Structure & Stability. These categories are directly affected by the act of arterial drainage with the over widening, over deepening of the channel and creation of a trapezoidal channel cross section. Low RHAT scores were also recorded in non-OPW channels with 4 out of 12 sites having unsatisfactory hydromorphological scores. This was due to river modification work (straightening, embanking, depending) possibly undertaken at the turn of the century.

4.3.7 Barrier Assessment on the Bonet Catchment for the Fish Population Index (FPI) Survey

Barriers to fish passage are identified as being a major impactor on anadromous species. The issue of barriers is relevant in the Water Framework Directive (WFD), in the context of hydromorphology and continuity. To this end a barrier assessment was undertaken on the Bonet Catchment to identify barriers to fish passage. This was achieved by combining a desk based survey, digitally identifying (using historical maps and recent aerial imagery) potential barriers with a field survey using electronic barrier survey forms developed for IFI. In total 198 potential barriers were identified in the Garavogue – Bonet Catchment using this technique (Table 4.2).

Table 4.2. Barrier types and their onsite assessment in the Garavogue – Bonet Catchment surveyed in 2016.

Structure Type	Identified as a Barrier	Identified as not a Barrier	Not surveyed/ No Access	Grand Total
Bridge	9	91	8	108
Ford		6		6
Footbridge		4		4
Level crossing		4		4
Riffle/Waterfall	1	12	3	16
Sluice	1	1		2
Stepping stones	1	9		10
Structure		4		4
Waterfall	17	5	1	23
Weir	9	12		21
	38	148	12	198

Of the 198 instream structures identified in the Garavogue – Bonet Catchment, 38 (19%) structures were characterized as potential barriers to fish passage. 18 of these structures were natural waterfalls or riffles and 20 potential barriers were identified as man-made obstructions. The majority of these man-made obstructions are bridges and weirs.

Structures in the Garavogue – Bonet Catchment were assessed in the field using the electronic barrier survey forms developed for IFI. This assessment outputs passability scores for different fish species (salmon Table 4.3 and Brook Lamprey 4.4), scoring their likely ability to pass the obstruction in the channel for the water condition on the date of survey.

Table 4.3. Barrier types and there possible effect on adult salmon passage in the Garavogue – Bonet Catchment surveyed in 2016.

Row Labels	Impassable	High Impact	Moderate Impact	Low Impact	No Barrier	Grand Total
Bridge	5	1		3	99	108
Ford					6	6
Footbridge					4	4
Level crossing					4	4
Riffle/Waterfall					16	16
Sluice		1			1	2
Stepping stones				1	9	10
Structure					4	4
Waterfall	5	4	3	4	7	23
Weir	2	2	5		12	21
	12	8	8	8	162	198

Table 4.4. Barrier types and their possible effect on river lamprey passage in the Garavogue – Bonet Catchment surveyed in 2016.

Row Labels	Impassable	High Impact	Moderate Impact	Low Impact	No Barrier	Grand Total
Bridge	5	2	2	1	98	108
Ford					6	6
Footbridge					4	4
Level crossing					4	4
Riffle/Waterfall				1	15	16
Sluice	1				1	2
Stepping stones	1				9	10
Structure					4	4
Waterfall	12	1	2		8	23
Weir	5	3	1		12	21
	24	6	5	2	161	198

The differing abilities of fish species to make passage over river obstacles are highlighted in Table 4.3 and 4.4. Adult salmon have greater jumping, burst swimming and sustained swimming abilities than river lamprey, resulting in higher number of "Impassable" scores recorded for River lamprey compared to adult salmon. Figure 4.19 and 4.20 show the distribution of barriers in the Bonet Catchment. A number of weirs and waterfalls are significant fish passage barriers on the main stem of the Bonet, the Scardawn and Owenmore rivers. Figures 4.12 are examples of man-made barriers on the Owenmore River, both these structures are partly natural rock outcrop augmented with concrete, they are upstream of the OPW drainage scheme. These structures represent "moderate" barriers to adult salmon and "impassable" barriers to lamprey *sp.*

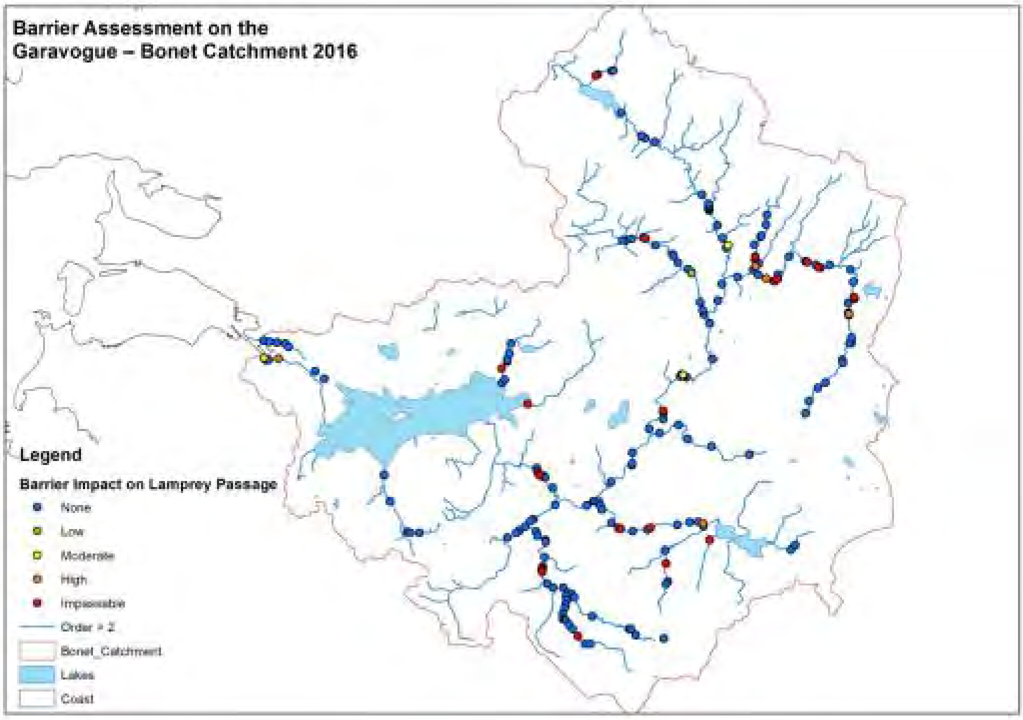

Figure 4.19. Assessment of the impact of barriers on lamprey *sp.* in the Bonet – Garvogue catchment 2016.

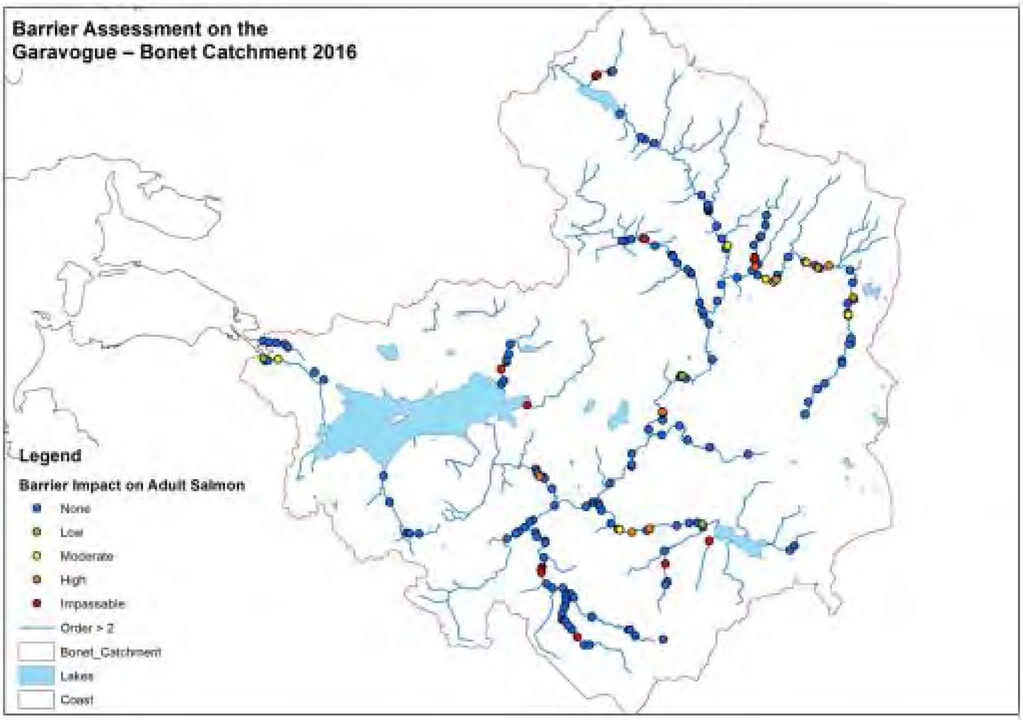

Figure 4.20. Assessment of the impact of barriers on adult salmon in the Bonet – Garvogue catchment 2016.

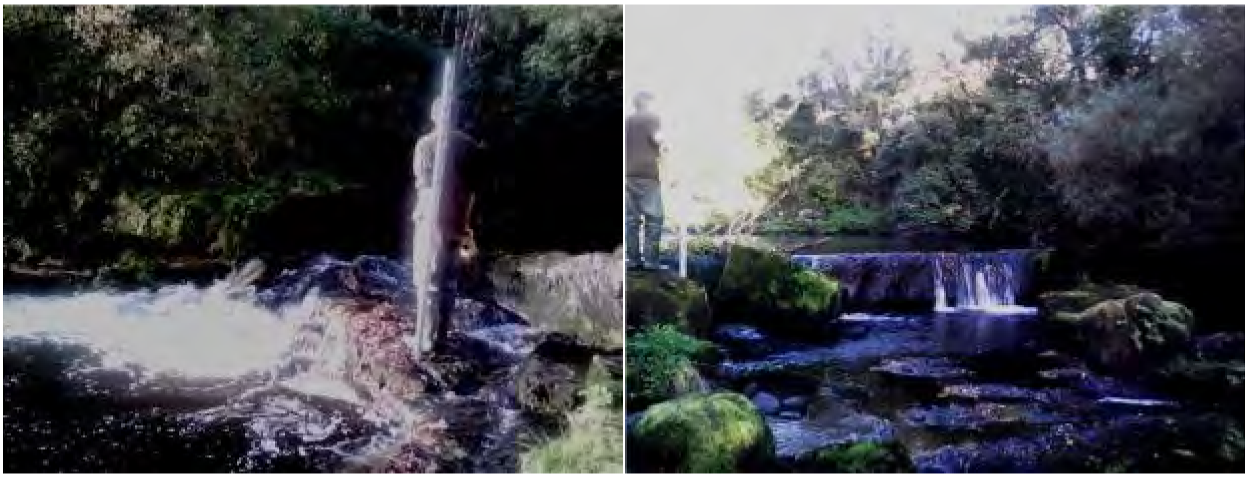

Figure 4.21. Man-made barriers on the Owenmore River, comprising of natural rock outcropping augment with concrete, surveyed October 2016.

The most significant barrier to fish passage on the Bonet River is the series of rock outcrops at the village of Dromahair. This series of waterfalls (Figure 4.22) represents a “high impact” barrier to adult salmon and an “Impassable” barrier to river and sea lamprey. However, juvenile lamprey (most probably brook lamprey) were recorded upstream of this structure. The main weir upstream of Sligo town needs further investigation as a potential barrier to sea lamprey passage.

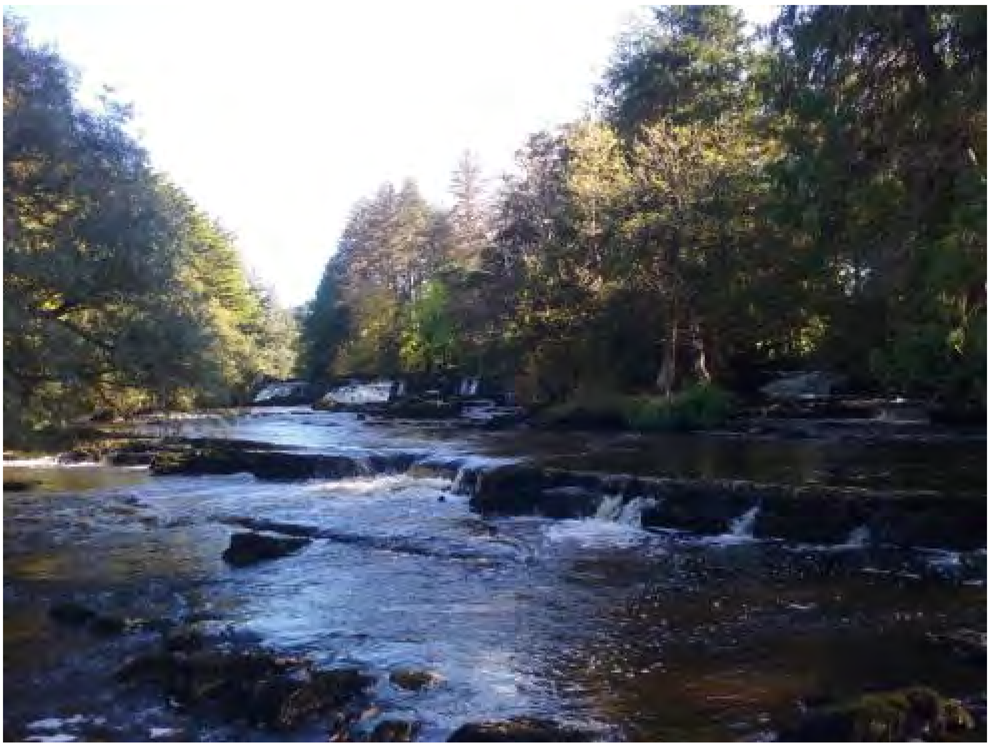

Figure 4.22. The natural rock out-cropping/ waterfalls at Dromahair on the River Bonet, surveyed October 2016.

The distribution of anadromous salmon in the Bonet catchment appears to be linked to the presence of natural and artificial barriers. Impassable natural barriers prevent the migration of adult salmon to the headwaters of both the Shanvas and Killanummery Rivers. High impact natural barriers may have a cumulative effect on salmon migration on both the Cashel stream and Owenmore Rivers, as successive high impact natural barriers impact on their migration.

Five manmade Barriers to fish passage were identified on OPW channels. 2 were augmented natural waterfalls, 2 were fords and one is an OPW Bridge (C1/3/2 B1). The Ford on C1/3 Sect C (8250) is the most serious identified, an impassable barrier to all fish species. This is not a designated OPW bridge. The Bridge on C1/3/2 designated B1, is a low impact barrier to salmonids but a high barrier to Lamprey *Sp.* This bridge barrier could represent an easy remediation exercise. The weir/waterfalls at C1 (18400) and C1 (8400) represent moderate and high barriers to salmonids and moderate and impassable barriers to Lamprey *Sp.* These two structures represent altered natural structures and would require careful consideration before any works were undertaken.

5 Crayfish Studies – update surveys in 2016

5.1.1 Background:

OPW-funded studies to examine the impacts of channel maintenance on the white-clawed crayfish (*Austropotamobius pallipes*) have been on-going since 2006 and have continued in the EREP studies that commenced in 2008. Survey channels are widely distributed among OPW catchment drainage schemes on limestone geology. In all cases, sampling was undertaken pre maintenance and at annual intervals, at same time of year, subsequently. In addition, post maintenance sampling was undertaken in the Brosna and Glore sites within weeks of the initial maintenance, as well as the annual post-works sampling.

The crayfish sampling programme examined crayfish population size and structure prior to- and in a series of years following maintenance. It was assumed that the sole variable on these large scale 'experiments' was that of change mediated by maintenance. The specific impact of maintenance on factors that might relate to crayfish ecology e.g. water depth (as a cover provider), level or nature of instream or marginal plant cover, type of channel bed, was not examined. As such, the findings to date presume an impact due to maintenance but cannot ascribe the maintenance impact to any single factor in any particular channel.

With up to 10 years of data collected it is apparent that two impact patters occur. In one of these the crayfish population declines to a very low level, commonly in the year after maintenance, and does not recover – even over an extended time period. In the second impact pattern there is evidence of a decline in crayfish numbers in the year following maintenance and this decline may be evident for one or more further years. However, a recovery in numbers occurs in these cases.

Given the time lapse of years since last monitoring, a selection of sites demonstrating these recovery patterns was surveyed in 2016 by IFI. The same sites, sampling gears and sampling effort were used as in the previous surveys in the selected channels. All channels were surveyed in the July – August period, at same time of year as previously. A total of five channels were investigated in 2016:

- Brosna Main stem was surveyed in 2007, pre-maintenance, and annually thereafter for five years from 2008-2012. This had shown signs of recovery in crayfish numbers after the initial maintenance work in 2007
- Tullamore River (Brosna CDS) was surveyed in 2006, pre-maintenance, and annually thereafter for four years from 2007-2010. This had shown signs of recovery in crayfish numbers after the initial maintenance work in 2007

- River Glore (Inny CDS) was surveyed in 2007, pre-maintenance, and annually thereafter for five years from 2008-2012. This had shown a decline in crayfish numbers, with no recovery, after maintenance in 2007.
- River Rath (Inny CDS) was surveyed in 2006, pre-maintenance, and annually thereafter for six years from 2007-2012. This had shown a decline in crayfish numbers, with no recovery, after maintenance in 2006.
- The Robe River (Corrib Mask CDS) sites had been subject to Capital Works at one location in 2009. Prior to works a Control and an Experimental pair of sites had been established in 2009 to monitor the impacts of the works programme on the fish and fisheries habitat. That study had included a monitoring of crayfish, which has high populations in the Robe system. Annual monitoring had been undertaken in the Robe paired sites from 2009 – 2014.

5.1.2 Results from 2016 studies

Brosna main stem: Recovery had been apparent in the 2008-2010 period following the initial maintenance in 2007. However, an unexplained collapse in numbers was recorded in 2011. This was again noted in 2012 and zero crayfish were recorded here in 2016.

Tullamore River: Up to eight discrete sites were fished for crayfish along the Tullamore River in the initial 2006-2010 period. A marked decline in numbers occurred in the year following maintenance. Two of the eight sites, Site 5 and Site 8 were re-surveyed in 2016. The overall trend over time for these two sites (Figure 5.1) showed the marked decline following maintenance followed by an intermittent presence in Site 8 with slightly higher levels there in 2016 compared to the 2007-10 post-impact period. Comparison of the 2006 and 2016 data sets for Site 8 indicated no significant difference in median values for the five replicates in each year (Mann Whitney $U = 6$, $p = 0.11$). Site 5 also showed the decrease in crayfish numbers following maintenance. Numbers were present at this site in all following years with a very gradual increase in numbers. The crayfish numbers in Site 5 in 2016 showed a marked increase over the recovery period (2007-10).

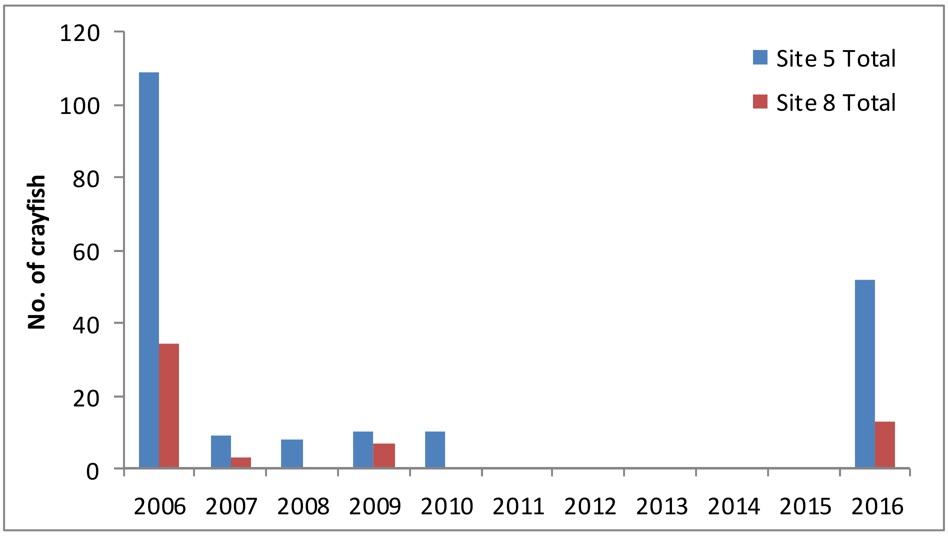

Figure 5.1. R. Tullamore: Crayfish numbers recorded in Sites 5 and 8 in the period 2006-2010 and in 2016. No surveys were undertaken in the period 2011-2015.

River Glore: In excess of 500 crayfish were collected in the five nets set in 2007 prior to maintenance. The following year less than 20 crayfish were taken for the same sampling effort. No crayfish were encountered in any of the nets set over the years 2009-2012. The sampling in 2016 had the same sampling effort and no crayfish were recorded. There has been no recovery of crayfish population in this study area following the maintenance work in 2007, nine years previously.

River Rath: This channel showed the same pattern of response to maintenance as in the River Glore. In excess of 200 crayfish were taken prior to maintenance in 2006, with a total of 39 captured in 2007, the year following maintenance. No crayfish were taken in any of the monitoring years 2009 – 2012. The sampling in 2016 again yielded zero crayfish. As with the River Glore above, there has been no recovery of crayfish population in this study area following the maintenance work in 2006, ten years previously.

River Robe: The Control – Experimental pair of sites at Sheepwash Bridge were set up to monitor the effect of a Capital Works project under EREP. The project commenced in 2009 with pre-maintenance data collection of fish, habitat, vegetation and crayfish data. The crayfish population was monitored annually from 2010, following maintenance, to 2014. The 2016 survey indicated the presence of crayfish in similar numbers in both study sites (Figure 5.2). The size range of crayfish (carapace length mm) was similar at both sites (Figure 5.3).

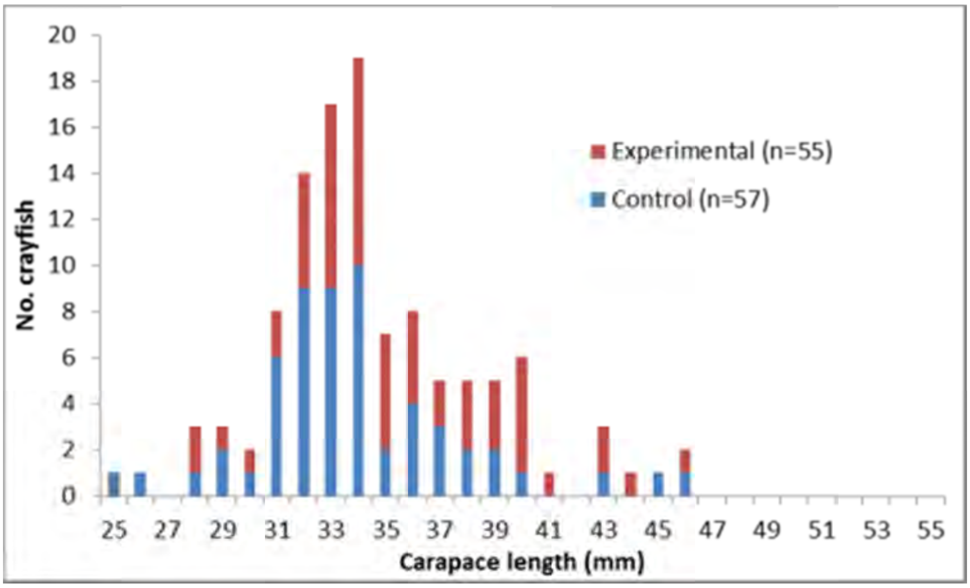

Figure 5.2. Length frequency distribution of crayfish in Control and Experimental sites on the River Robe, 2016.

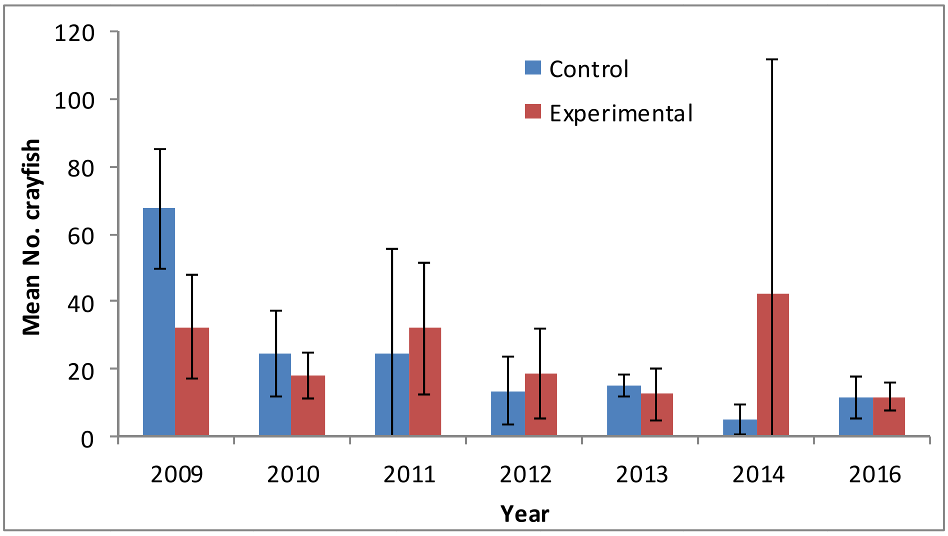

Figure 5.3. Comparison of mean crayfish numbers, with standard deviation, at the paired Control and Experimental sites in the R. Robe.

A review of data over the survey period indicated larger crayfish numbers in the Control site, compared to the Experimental, prior to instream works in 2009 (Figure 5.3). This difference was statistically significant (Mann Whitney U test, U=1, p=0.002).

Following treatment, the numbers in the Control site were significantly lower in 2010 compared to the 2009 pre-works data (Mann Whitney U test, U = 0, p = 0.001). This difference between pre- and post-works values was also noted in 2011. However, there was no significant difference in numbers between the two post-works years 2010 and 2011. The mean values in the two paired sites were broadly similar in years subsequent to completion of the instream works programme or ‘treatment’.

The EREP study has permitted continued monitoring and status assessment at sites previously examined in the EDM study and has allowed valuable long-term information to be complied. It is envisaged that a number of the crayfish sites reported on here would be examined again in 2018, in the context of OPW providing information to the NPWS for inclusion in status assessment of crayfish, under Article 17 of the EU Habitats Directive.

6 Hydromorphology – Barriers to fish passage in OPW channels

6.1.1 Introduction

The Water Framework Directive (WFD) identifies the importance of hydromorphology as an essential part of ecological quality. In addition, the term, as used in WFD, also takes in the concept of ‘connectivity’ or ‘continuity’. In the light of WFD, the issue of river continuity – and barriers to connectivity - has assumed an importance wider that a fisheries interest and a process of recording structures/barriers and of surveying them is now underway in Ireland. IFI is playing a lead role in this process. Two barrier assessment methodologies are employed by IFI, the standard IFI field assessment sheet (now digitized) and WFD III or SNIFFER barrier assessment protocol. IFI will utilize these tools in a two-phase assessment. Initially the digitized IFI field assessment sheet will be used to developing a national GIS-based information layer on ‘features’ or structures or barriers in Irish rivers. The WFD III method will be a second-phase assessment of specific structures impacting on target fish species in a catchment and that are earmarked for modification. In these cases, the WFD III assessment will be done before and after any modification.

Salmonids, lamprey, eels and shad engage in substantial migrations, linking spawning and recruitment grounds. In freshwater systems these species migrate significant distances, an adaptation that maximised species dispersal within a catchment. Barriers to fish passage are identified as either being natural or artificial. Natural barriers are generally of a geological origin (waterfalls). Artificial barriers are of man-made origin and take many forms. The majority were constructed to produce hydropower, supply water or to achieve a constant water level for leisure activities. These structures can have a pronounced effect on the flow regimes both down- and upstream of the barrier, affecting the aquatic species, their ecology and physical habitat.

6.1.2 WFD III Sniffer Barrier Assessments in OPW Channels 2016

Two structures were assessed using the WFD III SNIFFER barrier assessment tool in 2016, the Cadamstown Sand Trap on the Kilcormac Silver (Brosna Tributary: C3(1)) and Ballycahill Weir on the Kilcrow River (Cappagh/Kilcrow (Killimor scheme) Tributary: C1 Ch:12600).

The sand trap on the Kilcormac Sliver is located approximately 500m from the top of the OPW scheme, north of Cadamstown. Its function is to trap sediment and prevent its migration downstream through the system. The sand-trap was surveyed in summer low flow conditions (25/5/2016). The structure is approximately 55m long and presents a complete barrier to fish passage in low flow conditions. The structure is comprised mostly of a long (~40m) sloping concrete lined floor, with a drop at the downstream end and a fish pass structure at the upstream end (Figure 6.1). The initial drop presented to fish attempting passage is 0.62m. Fish would then need to swim the 40m of shallow fast flowing water before reaching the fish pass at the top of the structure. The fish pass at the upstream end has been designed for salmonids with a hydraulic head of 0.43m between each box.

Apart from juvenile eels, the Cadamstown Sand-trap represents a complete barrier to migratory fish passage in low flow conditions. In high flow conditions it presents a partial barrier high impact to salmonids and a complete barrier to cyprinids and lamprey. Eels will make passage in all flow conditions by using climbing substrate on the rivers margins.

Figure 6.1. Cadamstown Sand Trap on the Kilcormac Silver (Brosna Tributary: C3(1)), Fish pass (top) and downstream end of structure (Bottom) showing drop and long concrete sill.

Ballycahill Weir on the Kilcrow River (Killimor scheme C1, Ch:12600) is located south of Killimor. This weir was constructed to feed Ballycahll mill with water power to process corn. The weir apron begins approximately 25m upstream of Ballycahill Bridge. This structure was assessed in summer low flow conditions (25/5/2016), the bypass channel was not receiving any water at the time and therefore could not be assessed. At time of survey the weir in Ballycahill presented two potential fish passage options - the overflow sluice and the fish pass (Figure 6.2).

Figure 6.2. Fish passage options at Ballycahill Weir (25/5/2016), overflow sluice top, fish pass bottom.

Apart from juvenile eels, Ballycahill weir represents a complete barrier to migratory fish passage in low flow conditions. Any fish passage via the overflow sluice is impossible due to the height of the jump required (1.57m) and the lack of any plunge pool (0.001 m). Fish passage through the fish pass was calculated to be impossible due to its high slope (15.92%), lack of water depth (< 0.04m) and high water velocities (Average 2.52 m/sec, StDev ±0.86). In high flow conditions adult salmonids will make passage as this structure becomes a high impact partial barrier, however in high flows Ballycahill weir remains a complete barrier to juvenile salmonids, cyprinids and lamprey.

Where it is proposed to undertake modifications for fish passage at any of the structures surveyed the outcome of the SNIFFER III survey is compiled into a report that accompanies documentation submitted to the relevant Local Authority for planning permission. The quantification provided by the SNIFFER method is considered to be valuable in providing data supporting a reasoned rationale for the proposed planning. During 2016 IFI compiled relevant documentation for planning in regard to a weir at Martry Mill on the R. Kells Blackwater (Boyne CDS) on foot of SNIFFR surveying conducted under EREP in 2015. It is envisaged that further SNIFFER surveys will be undertaken on significant fish passage structures in OPW catchments in 2017 and beyond. These may be of particular significance where the OPW scheme lies within a designated SAC for salmon or lamprey species.

7 Going forward – development of EREP in 2017 and beyond

As mentioned previously, the Capital Works component of EREP has proved to be highly manpower-intensive. Coupled with the low level of implementation of the works designs, on a year-by-year basis, IFI has had to further rationalise its involvement in the EREP study going forward into 2017. This rationalisation relates to both the Capital Works design and to the auditing processes.

A series of measures were identified and agreed for advancement as part of an EREP programme for 2017. These included both desk-based and field-based elements:

- Review of the 10 steps to environmental maintenance
- Review of current gravel/sand traps in OPW drainage schemes and potential to dismantle these, as a hydromorphology measure to reinstate natural bed load transport in the downstream channels and facilitate fish passage
- Review of instream works measures in the context of WFD hydromorphology
- Desk-based study to examine a small number of meanders to assess feasibility of re-connecting these to the current channels in specific flow conditions in context of biodiversity and wetland habitat creation
- Catchment-wide fish and hydromorphology survey: Commence 2-year programme on Inny catchment (2017-18) to complement barriers survey (below), to cover C7 – C32.
- Barriers survey: - commence a 2-year programme on the Inny catchment, to cover channels C7 – C32 i.e. from L. Ree upstream to Ballinalack. GIS layer compiled for Q4.
- Long term data set development: Proposed re-survey of the R. Clodiagh (C8 Brosna), first examined in 1996. This is intended to link in with a proposed experiment to look at use of woody material removed in maintenance for use as low-level instream structures, to replace rock material
- IFI to provide annual national overview and GIS layers in respect of data collected

The proposed continuation of the catchment-wide fish and habitat (RHAT) survey programme permits generating EQR (ecological Quality Rating) scores for sites. These scores provide an indication of ecological quality, as required by the Water Framework Directive, and will indicate status of sites on OPW channels, where original arterial drainage as well as on-going maintenance, have been undertaken. There are five levels of 'quality' – High, Good, Moderate, Poor and Bad. The WFD requires that sites should all achieve at least Good status and tha tHigh status status shuodl remain at that level.

IFI will continue a programe of long-term monitoring of sites. The extended duration of EDM and EREP has meant that long-term impact studies are possible. A frequent shortcoming of monitoring studies is that they do not run for a sufficiently long period after completion. The available time span (1990 – 2015) has allowed for long term monitoring of arterial drainage works (e.g. Monaghan Blackwater); long-term impact of river enhancement works (e.g. TAM works on the Moy and Corrib catchments from mid-1990s); studies on environmental maintenance impacts on fish, instream and riparian features (e.g. EDM studies from 1997 – 2007 reviewed in 2012 *et seq*.)

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