Snorkel and Glochidia Survey for Freshwater Pearl Mussel in the River Allow (Upper Blackwater SAC) - Monitoring Report

Action E3

LIFE09 NAT/IE/000220 BLACKWATER SAMOK

April 2016

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I.R.D. Duhallow Ltd.

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Executive Summary

Twenty-three kilometres of riverbed was surveyed by snorkelling with a total count of 17,609 individual FPM. This equates to approximately 0.13 FPM per metre of riverbed, or 130 FPM per kilometre. The majority of FPM were located in glide habitats (54%), followed by pools (21.6%) and riffles (12.8%). The FPM found in pools were typically on the edge of pools, rather than in the deeper section. As pools were located directly downstream of ripples, the FPM found in pools could have been deposited there during flood events.

The amount of silt deposited on the riverbed had a statistically significant effect on the distribution of FPM in the River Allow. More FPM were found in areas of where silt was absent, light or considerable compared to areas of heavy and excessive levels of silt. Even though the mean number of FPM was higher in areas with lower silt levels, most FPM were counted in areas with heavy siltation, reflecting the high levels of silt currently entering the River Allow.

On average, there were more mussels grouped together on bedrock, than on other substrates (except boulders). Research suggests that the preferred habitat for FPM in terms of substrate size is sand-patches stabilised by large stones (Skinner et al., 2003), with boulder sheltered mussel beds being critical after heavy floods because they provide protection (Vannote and Minshall, 1982). The majority of FPM were counted on cobble (57.7%) which probably reflects the predominantly cobble structure of the riverbed. However, the FPM's preferencial use of boulders for protection might explain the high means recorded for the bedrock and boulder groups.

Point source discharges are having an effect on the viability of FPM in the Allow. The IRD Duhallow LIFE+ Project team responded to several industrial discharges from various sources in the Allow catchment. No FPM live in the River Allow downstream of Kanturk town.

The presence of glochidia in all sites monitored in the Allow catchment is significant and points to FPM reproduction taking place. If Ireland is serious about protecting the FPM, then urgent action is required to address both point source pollution (e.g. industrial discharges), and diffuse pollution (e.g. agricultural, forestry, storm water runoff etc.) in all FPM rivers.

Background

Current status

The Freshwater Pearl Mussel (FPM) (*Margaritifera margaritifera*) is a species of mollusc, found in rivers. Their distribution ranges from the Arctic and temperate regions of western Russia, through Europe and out to the north-eastern seaboard of North America. However, in recent years its numbers have suffered dramatic declines (Skinner et al., 2003) and the species is now listed as vulnerable on the IUCN invertebrate red list.

In Ireland it is afforded significant protection under the Habitats Directive (92/43/EEC) and the Wildlife Acts (1976, amended 2000). As a result, it is illegal to interfere with FPM (Statutory Instrument No. 112, 1990), and pearl harvesting, something which was wide-spread in the past due to the pearls which some individuals produce, is now an illegal activity. The FPM, while previously widespread across Europe, is now extinct in most countries. Populations with some juvenile recruitment are found in Scotland, Finland, Sweden and Ireland. Ireland holds some of the larger populations (ASMP, 2010), and are geographically widespread in rivers with low pH (Figure 1). Geist (2005) estimates that the Republic of Ireland has 12 million individuals, or approximately 46% of the EU population (Geist, 2005). However, the high number of individuals negates the seriousness of recent population declines with a review of the conservation status of *Margaritifera margaritifera* finding them to be "critically endangered" in Ireland (Moorkens, 2006).

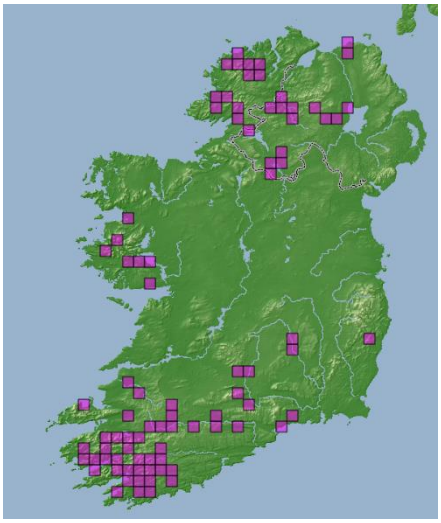

Figure 1 FPM distribution within Ireland

FPM Life cycle

The FPM have a complex life-cycle. It is generally found in coarse sand or gravel beds in fast flowing rivers, where it lives partially buried in the sediment. It feeds by filtering water through its siphons, absorbing nutrients from this water. Mussels can live for up to 100 years (Comfort, 1957) and develop slowly, maturing between 7 and 15 years of age (Meyers and Milleman, 1977). It is a dioecious species and it reproduces when males release sperm through their exhalant siphons. The sperm is inhaled by the female mussels through their inhalant siphons, where they meet with the eggs. The fertilised eggs then develop in pouches inside the females

for several weeks, after which the larvae, known as glochidia, are released into the river (Skinner et al., 2003). In Ireland this usually occurs in the months of August and September, in a synchronised manner over a period of approximately two days (Hastie and Young, 2001). The glochidia then attach themselves to passing salmonid fish (Bauer and Vogle, 1987), which serve as temporary hosts (Figure 2). Brown trout are the main host species in Ireland (Beasley 1996), but glochidia also attach to Atlantic salmon.

Moorkens (1999) found insufficient evidence to say that the glochidia disable the host fish, however a recent study showed high loads of glochidia can pose a significant respiratory burden on brown trout (Thomas et al., 2013). The FPM eventually drop off the fish and land on the river-bed, burying themselves down into the gravel or sand. They stay buried, filter feeding the water that permeates the substrate, until they are mature enough to emerge and withstand the fast-flowing water.

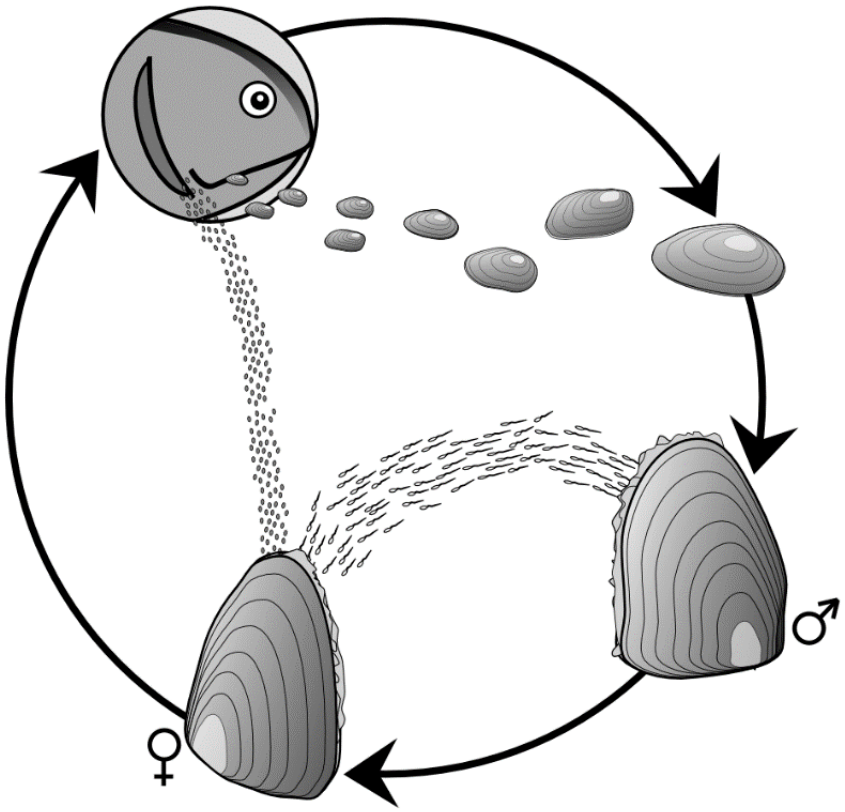

Figure 2 FPM life cycle. Source: Kim Lindgren - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1872403

FPM Threats

Freshwater Pearl Mussels only tolerate clean water and will eventually perish with even low to moderate levels of water pollution (Skinner et al., 2003). As such, poor water quality is a major threat to their long term sustainability and survival.

The loss of FPM populations mostly occurs from the continuous failure to produce a new generation of mussels when clean gravel beds are lost due to the infiltration of fine sediment. This blocks the required levels of oxygen from reaching young mussels. The 5-year period in which the juvenile mussels are buried is one of the most vulnerable parts in their life-cycle (NS 2, 2010).

As FPM are filter feeders, ingestion of toxic pollutants from industry and agriculture can kill FPM outright if it gets into the freshwater system. For a FPM population to be sustainable, both chronic and once-off pollution incidents must be prevented. Furthermore, eutrophication affects FPM by encouraging filamentous algae and macrophyte growth which covers the substrate making it uninhabitable for FPM. Potential sources of nutrients include point source discharges from factories and municipal buildings such as waste water treatment plants, and diffuse pollution from agricultural sources like farming and plantation forestry. The decline in the host-stocks (e.g. salmon and trout) is another threat (Buddensiek, 2001; Anon, 2005).

Figure 3 Effects of eutrophication leads to excessive macrophyte growth on the River Allow

FPM populations in the Munster Blackwater River

The Munster Blackwater and its sub-catchment the River Allow provide habitat for the FPM, and are designated as a Special Area of Conservation under the EU Habitats Directive (Site code 002170). Historically, this Annex II species was widely distributed in the Munster Blackwater, and anecdotal evidence suggests it was formally abundant in the River Allow. Investigations undertaken by IRD Duhallow and Inland Fisheries Ireland (Igoe and Campion 2009) found that the habitat of FPM was severely degraded in the River Allow.

The River Allow Freshwater Pearl Mussel Sub-Basin Management Plan state that the population of FPM is in an unfavourable condition in the areas surveyed on the Allow. It is currently ranked as 12th out of the 27 Freshwater Pearl Mussel SAC populations in the country on the basis of population status, habitat condition and current pressures. The management plan states (NS 2, 2010 p.96):

"The population was found to be failing in its habitat quality (through evidence of heavy siltation and strong macrophyte growth), and in its population demographic profile, where it is evident that there are not the numbers of juveniles present in the population to provide sustainable replacement of the current adult numbers."

Figure 4 Algae (left) and silt (right) covering mussel beds in the River Allow

Site Description

The River Allow catchment is 310km^2 (Figure 5). The three major rivers that drain the catchment are the Allow, Dalua and Brogeen. The main land use in the catchment is agricultural, with pasture based dairying and beef production of most importance.

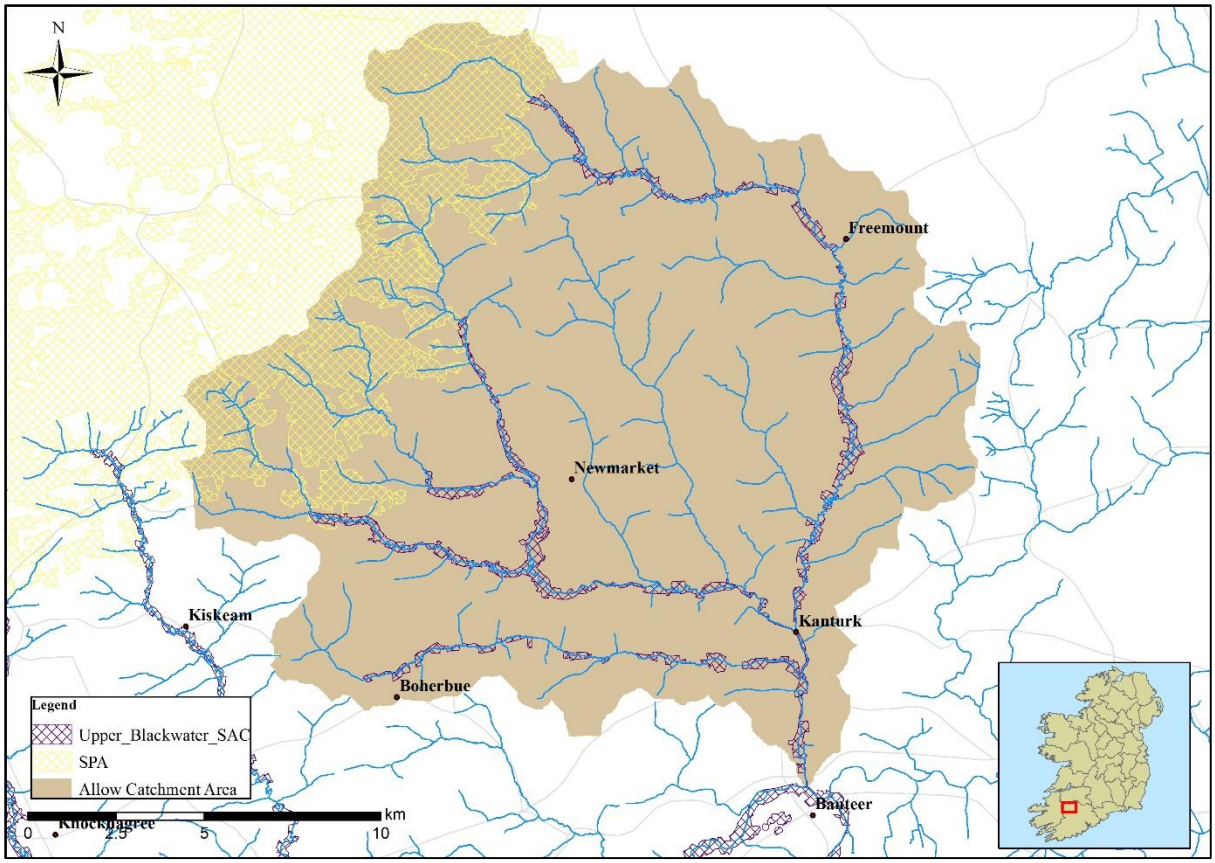

Figure 5 River Allow catchment area targeted by the DuhallowLIFE Project (LIFE09 NAT/IE/000220 Blackwater SAMOK)

The majority (70%) of soil in the Allow catchment is deep, poorly drained mineral soil. Blanket peat covers approximately 5% of the catchment, mostly in upland reaches. Mineral alluvium is associated with the river channels, while shallow well drained mineral soils make up the remaining soil type in the catchment (Tedd, 2014).

The Allow catchment rivers (Allow, Dalua, Brogeen, Glenlara and Owenkeale) form part of the Blackwater River (Cork/Waterford) Special Area of Conservation (Natura 2000 site code: 002170). These tributaries provide important habitat for FPM, Atlantic salmon (*Salmo salar*) and European otter (*Lutra lutra*), all of which are listed in the Annex II of EU Habitats Directive. The upper reaches of the Allow catchment contain the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle Special Protection Area, which was designated as such for Hen Harrier (*Circus cyaneus*) (listed in Annex I of the EU Bird's Directive).

Methods

Freshwater pearl mussel survey

The project team met with NPWS personnel and were informed that a FPM survey license would be required. Qualified trainer Dr Evelyn Moorkens provided training, then a license to commence the survey using stage 1 and 2 methodologies (discussed below), which was approved in 2011. The licensed surveyors were Dr. Fran Igoe, Kieran Murphy, Christy Healy and Dr. Evelyn Moorkens. The survey was carried out on the River Allow in 2012 and 2013. The survey covered 23km from Glashawee in the headwaters, down to Coolageela and Kanturk. Stage 1 and 2 survey techniques set out in the Irish Wildlife Manuals No. 12 (NPWS, 2004) were adhered to for the survey work. In addition to the licensed surveyors working in the river was a river bank manager (Nuala Riordan), who coordinated the work and recorded the data during the survey.

Stage 1 - Bathyscope

Stage 1 surveys establish whether there are adult FPM in a river. This is a presence/absence survey based on searches of those sections of a river exhibiting features most likely to support FPM. In water less than 75cm deep, the search was conducted with a bathyscope via wading (working from the bank is not sufficiently reliable to be admitted as a basis for survey). This method has the potential to damage the mussels by trampling, so when mussels are found in a stretch of river, Stage 2 methodology was used.

Stage 2 - Snorkelling

Stage 2 surveys estimated the adult FPM population within the survey site. Quantitative FPM surveys cannot be reliably carried out using a bathyscope and waders. Therefore, the river was split into sections and surveyed by snorkelling. In sections of the river with large numbers of FPM, a pre-determined number of transects were surveyed per kilometre of riverbed. In sections of the river where FPM were less numerous, all mussels present were counted for a 500m transect per kilometre of riverbed surveyed. Counts of FPM were recorded via the methods outlined in NPWS (2004).

Recording habitat parameters

At locations where FPM were present, the GPS location was taken and the following parameters recorded: number of FPM, macro-habitat, water depth, river substrate, degree of siltation, distance from the river-bank, and any additional relevant information such as bankside vegetation or amount of algae/macrophyte growth was also recorded. All data were recorded on a survey sheet, then transferred to MS excel and a Geographical Information System (Arc GIS).

Macro-habitat was classified using the riffle-pool sequence. This sequence categorises sections of meandering rivers into a riffle, glide, pool or slide. The river substrate and level of siltation was visually assessed using the substrate types defined by the Environmental Protection Agency (EPA). The EPA divide substrate types into bedrock, boulder (>128mm), cobble (32-128mm), gravel (8-32mm), fine gravel (2-8mm), sand (0.25-2mm) or silt (<0.25mm).

Statistical Analysis

SPSS was utilised to generate summary statistics, including the mean number of FPM located within different parameters (macro-habitat type, degree of siltation, substrate). The data was graphed using bar-charts displaying the mean values with standard error bars (+/-2 se).

ANOVA statistical tests were conducted on each of the parameters to determine if any had a statistically significant influence on the distribution of the FPM in the River Allow. These tests provide a p-value for each parameter. A p-value less than 0.05 indicated that a parameter was significant. For each parameter found to be significant, a follow up Tukey HSD (Honestly Significant Difference) test was undertaken to determine which of the levels within the parameter were significantly different from one-another.

Brown trout and salmon survey

The purpose of the survey was to ascertain the presence or absence of Glochidia on salmonid hosts in the Allow and Dalua Rivers. The survey was undertaken by IRD Duhallow LIFE+ team in co-operation with Kanturk Anglers.

In order to protect the captured fish the survey was conducted by catching the fish by rod and line. Two anglers were involved in the survey, Michael Twohig and Denis Cronin.

All fish were caught by either upstream dry fly or nymphs fished upstream. Both methods were employed over the six sites sampled. All fish were netted and examined by personnel for the presence of glochidia on their gills. The fish were placed in water containers to aid recovery and were returned to the area in which they were taken from.

A wide range of river habitats were sampled with each survey site fished encompassing a selection of riffles, pools and glides. Five sites were fished on the Allow and one site on the Dalua. Prior to fishing all survey staff were briefed on sampling methodology and issued with sampling packs. Sites were chosen to reflect different areas of the river from the source to lower reaches.

Results

Freshwater pearl mussel survey

A total length of 23km was surveyed quantitatively with a total count of 17,609 individual FPM (Figure 6). This equates to approximately 0.13 FPM per metre of riverbed, or 130 FPM per kilometre.

Table 1 Counts of individual FPM by substrate and macro-habitat categories.

Substrate	**Macro-habitat**				**Total**
	Riffle	*Glide*	*Pool*	*No data*	
Fines	1	143	374	109	627 (3.6%)
Sand	6	70	70	8	137 (0.8%)
Gravel	491	1588	763	244	3086 (17.5%)
Cobble	1173	6054	1618	1280	10125 (57.5%)
Boulder	111	956	369	180	1616 (9.2%)
Bedrock	473	708	713	124	2018 (11.5%)
Total	2255 (12.8%)	9519 (54%)	3890 (21.6%)	1945 (11%)	**17609**

Table 2 Counts of individual FPM by substrate and degree of siltation categories.

Substrate	**Degree of siltation**						**Total**
	None	*Light*	*Considerable*	*Heavy*	*Excessive*	*No data*	
Fines	3	0	15	77	532	0	627 (3.6%)
Sand	3	23	17	57	37	0	137 (0.8%)
Gravel	569	801	486	586	614	30	3086 (17.5%)
Cobble	1671	1820	3173	1952	1304	205	10125 (57.5%)
Boulder	119	428	513	341	189	26	1616 (9.2%)
Bedrock	209	494	550	159	105	501	2018 (11.5%)
Total	2574 (14.6%)	3566 (20.3%)	4754 (27%)	3172 (18%)	2781 (15.8%)	762 (4.3%)	**17609**

Macro-habitat

The majority of FPM were located in glide habitat (54%), followed by pool (21.6%) and riffle (12.8%) (Table 1, Figure 6). The FPM found in pools were typically on the edge of pools, rather than in the deeper section. As pools were located directly downstream of ripples, the FPM found in the pools could have been deposited there during flood events.

There were no statistically significant differences between flow group (glide, riffle, pool) means as determined by one-way ANOVA (F (2,2608) = 1.826, p = 0.161) (Table 3).

Table 3 Results of one-way ANOVA for macro-habitat

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	713.386	2	356.693	1.826	.161
Within Groups	509402.613	2608	195.323		
Total	510115.998	2610			

Substrate

The type of substrate had a significant effect on the number of mussels recorded within a stretch (F (5,2929) = 5.801, p = 0.001) (Table 4). Bedrock was the only substrate that had a statistically significant difference in the mean number of FPM compared to other substrates (fines, gravel, cobble). The majority of FPM were counted on cobble (57.7%) and gravel (17.5%), which probably reflects the predominantly cobble nature of the riverbed, and the FPM's preference for gravel (Figure 6).

Table 4 Results of one-way ANOVA for substrate

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5246.072	5	1049.214	5.801	.001
Within Groups	529796.928	2929	180.880		
Total	535043.000	2934			

Siltation

The degree of siltation had an effect on FPM distribution (F (4,2839) = 7.669, p = 0.001). Heavy and excessive levels of silt have statistically significant lower means than the considerable, light and none groups. Even though the mean number of FPM was higher in areas with lower silt levels, most of FPM were counted in areas with heavy siltation, reflecting the high levels of silt currently entering the River Allow (Table 5, Figure 6).

Table 5 Results of one-way ANOVA for siltation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5583.243	4	1395.811	7.669	.001
Within Groups	516733.200	2839	182.012		
Total	522316.443	2843			

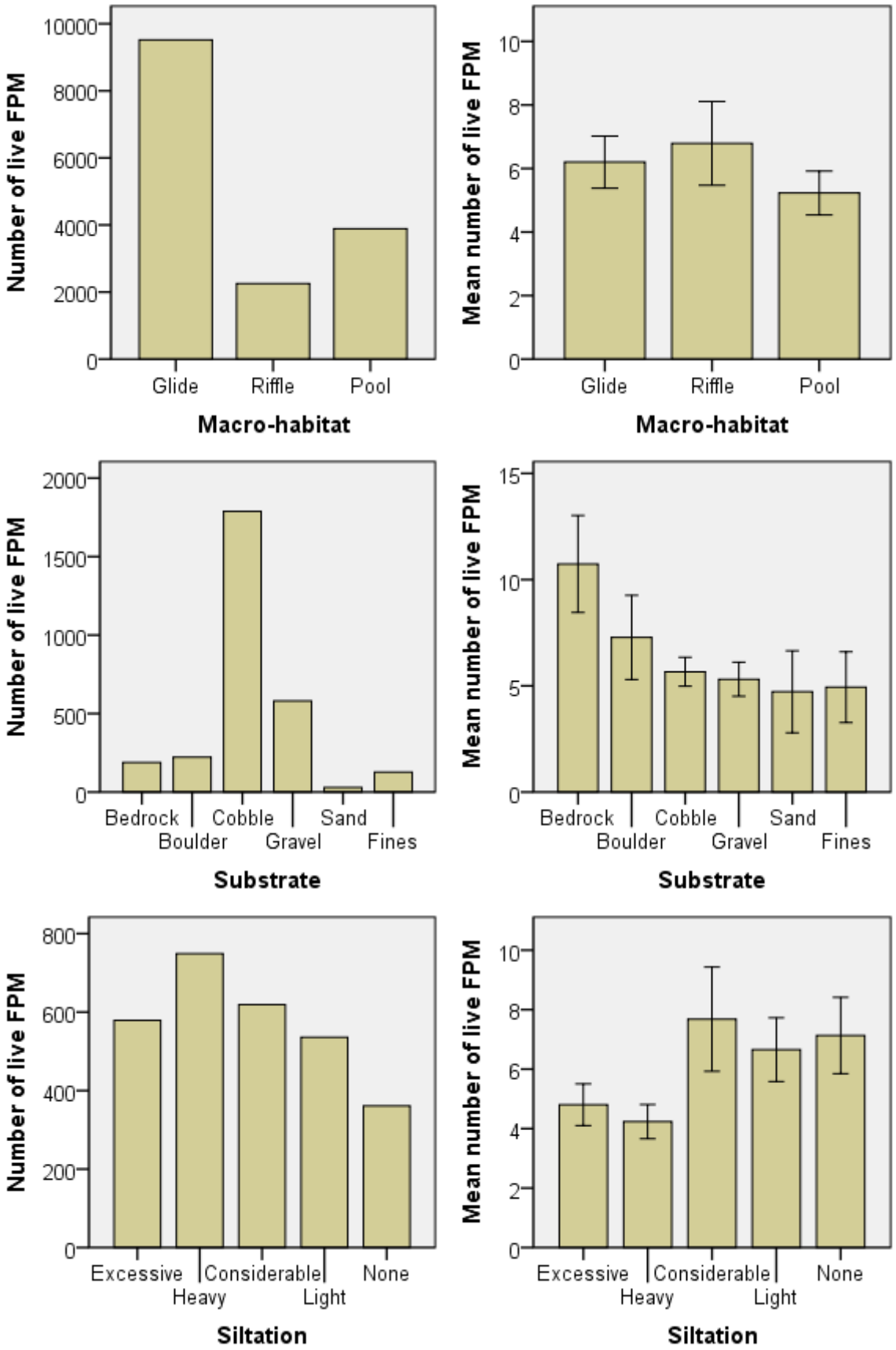

Figure 6 Total counts and mean counts of FPM in different macro-habitat, substrate, and siltation groups.

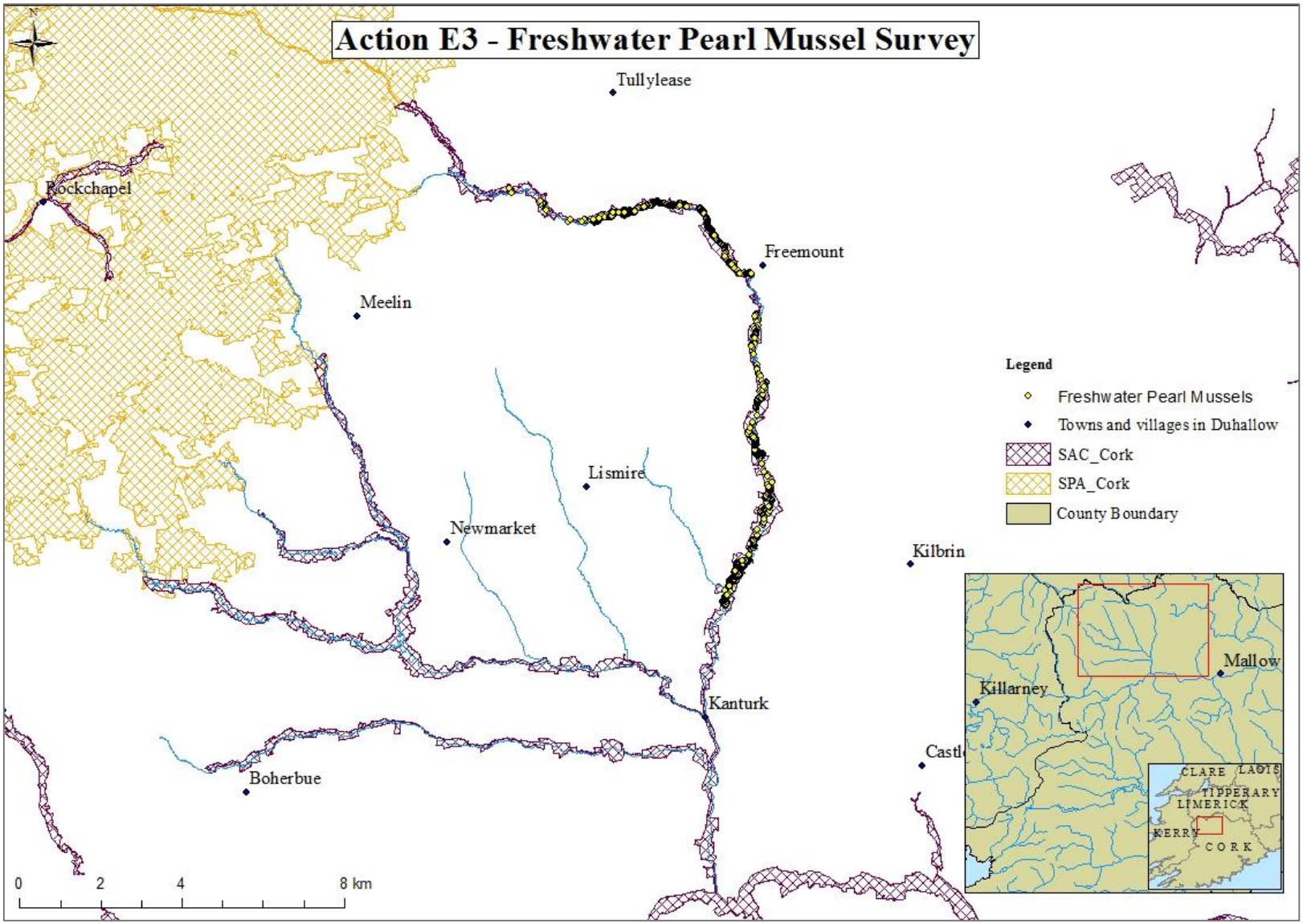

Figure 7 Freshwater Pearl Mussels counted on the River Allow

Figure 8 Results of FPM snorkel survey downstream of water treatment plant discharge. Note live FPM (green) upstream of discharge (X), and dead FPM (red) downstream

Brown trout and salmon survey

A total of 77 trout and four salmon were caught at the five sites (Figure 9). Of those fish, 45 (58%) of trout and 3 (75%) of salmon had glochiodia present, and on 32 (42%) of trout, and a 1 (25%) of salmon, glochidia was absent. Glochidia were present in all sampled areas (Table 3). Fish length varied from 7cm to 30cm. The smallest fish (7cm) were only caught at Freemont and the largest (30cm) caught at Raheen Bridge.

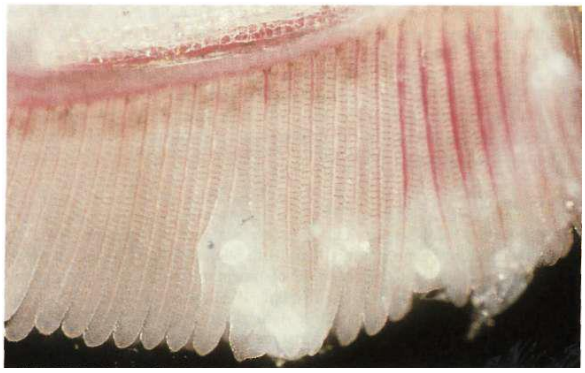

Figure 6 Salmon gill, showing encysted Glochidia of M. margaritifera (Young, 1984)

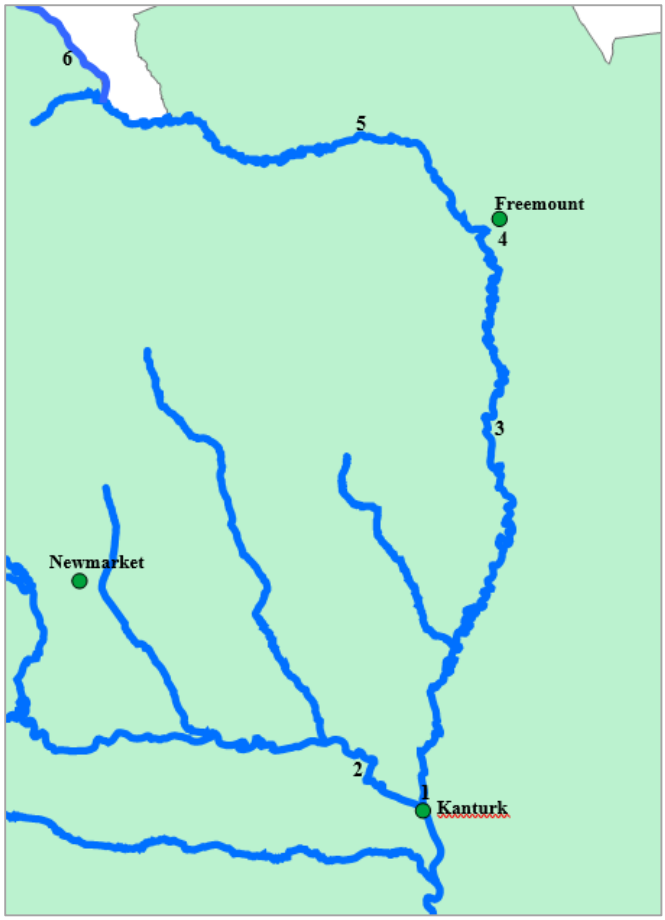

Figure 7 Survey Site Map (1, Currah (Allow); 2, Curragh (Dalua); 3, Ballybahallagh; 4, Freemount; 5, Raheen; 6, Rowls Langford North

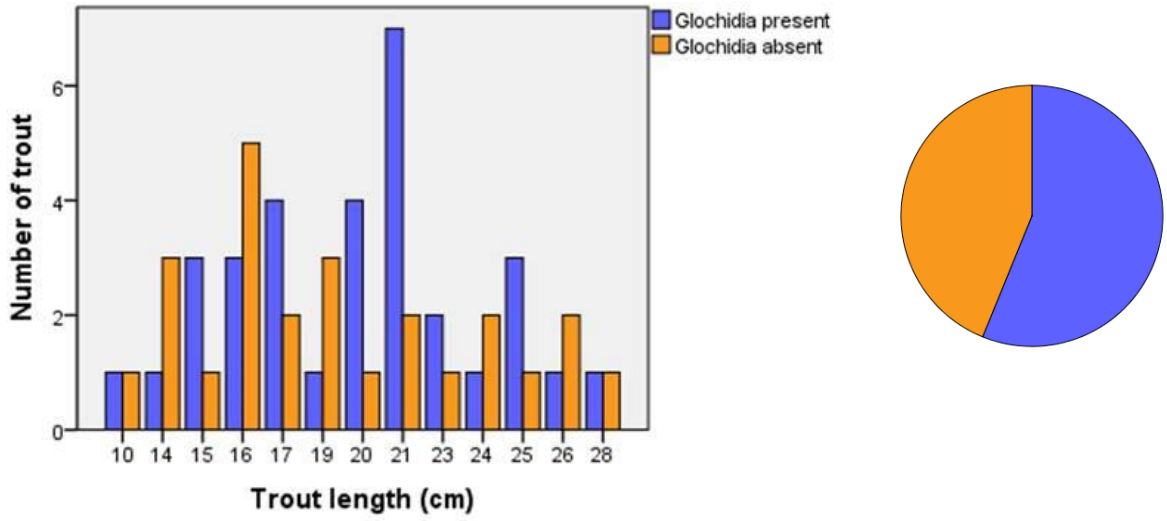

Figure 10 Number of trout by length with glochidia present and absent for all sampling sites

Table 6 Number of trout and salmon with glochidia present and absent

Sites	Glochidia on trout (t), and salmon (s)		
	Present	Absent	Total
Curragh (Allow)	10t (59%)	7t (41%)	17t
Curragh (Dalua)	2t (40%)	3t (60%)	5t
Ballybahallagh (John's Bridge)	13t (76%)	4t (24%)	17t
Freemount	6t (38%) 3s (75%)	10t (63%) 1s (25%)	16t 4s
Raheen Bridge	11t (61%)	7t (39%)	18t
Rowls Langford Nth (Hayes' Cross)	3t (75%)	1t (25%)	4t
Total	45t (58%); 3s (75%)	32t (42%); 1s (25%)	77t; 4s

The results of the trout and salmon survey broadly reflect a wide ranging distribution of Glochidia throughout the Allow River. However, the sampling of the Dalua only consisted of one site in the lower reaches of the river and more sites are required to get an accurate view of Glochidia distribution. Glochidia were observed on the gills of trout captured in the Dalua. There are no reports documenting the presence of adult FPM in Dalua

Glochidia were recorded at all monitoring sites. The highest proportion of glochidia to caught fish was at Johns Bridge with 75% of the caught trout carrying glochidia (Figure 11). This reach had a reasonably stable substrate and stable shaded banks with low levels of erosion. This reach provided good habitat for FPM, with relatively slow flow and large cobble substrate.

The area with the lowest proportion of glochidia to caught fish was at Freemount with 38%. This site suffers from heavy levels of siltation and as such, may not contain the necessary substrate for FPM. Furthermore, the collapse of the FPM population directly downstream from the discharge point at the Freemount water treatment plant would have restricted FPM recruitment.

The fact that Glochidia were found on trout from the Dalua warrants further investigation as this river is not listed as having a population of FPM.

A geographic partition is apparent in the survey results with lower reaches having glochidia present at higher percentages than mid or higher reaches of the river. The results suggest that there is FPM breeding on the River Allow. However, the study did not account for fish migration and associated transport of glochidia up the river. It is possible that the fish sampled had transported glochidia from the main Blackwater channel, or other tributaries and areas of the Allow catchment. Fish migration could also be responsible for glochidia in the Dalua.

The small number of Atlantic salmon caught in the survey is of concern. Previous electrofishing results indicate that the Allow has poor to moderate stocks of Atlantic salmon juveniles. This could be a result of the elevated levels of silt overlying the river gravel beds which are necessary for salmon spawning and nursery purposes.

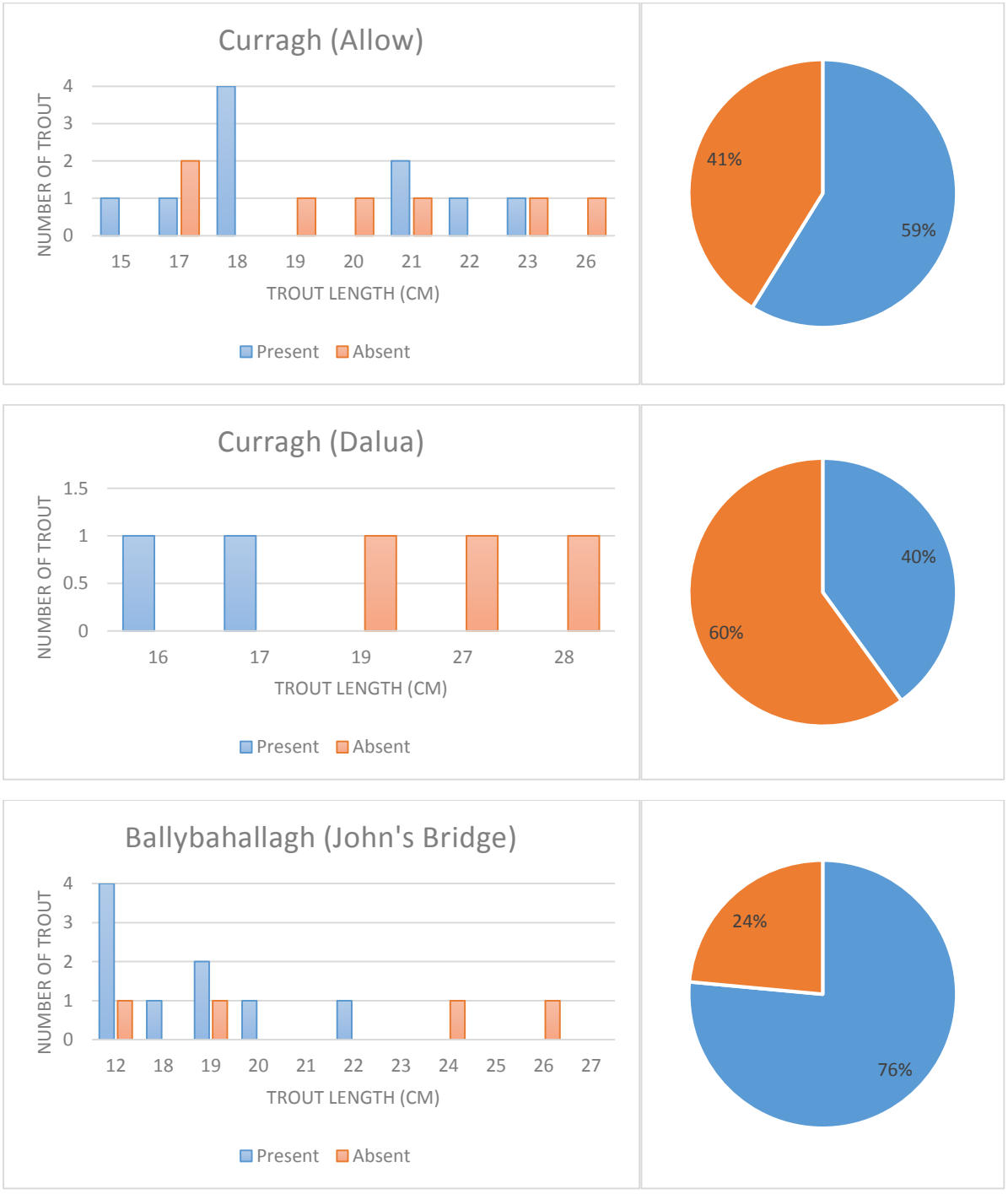

Figure 11 Number and length of trout with and without the presence of Glochidia

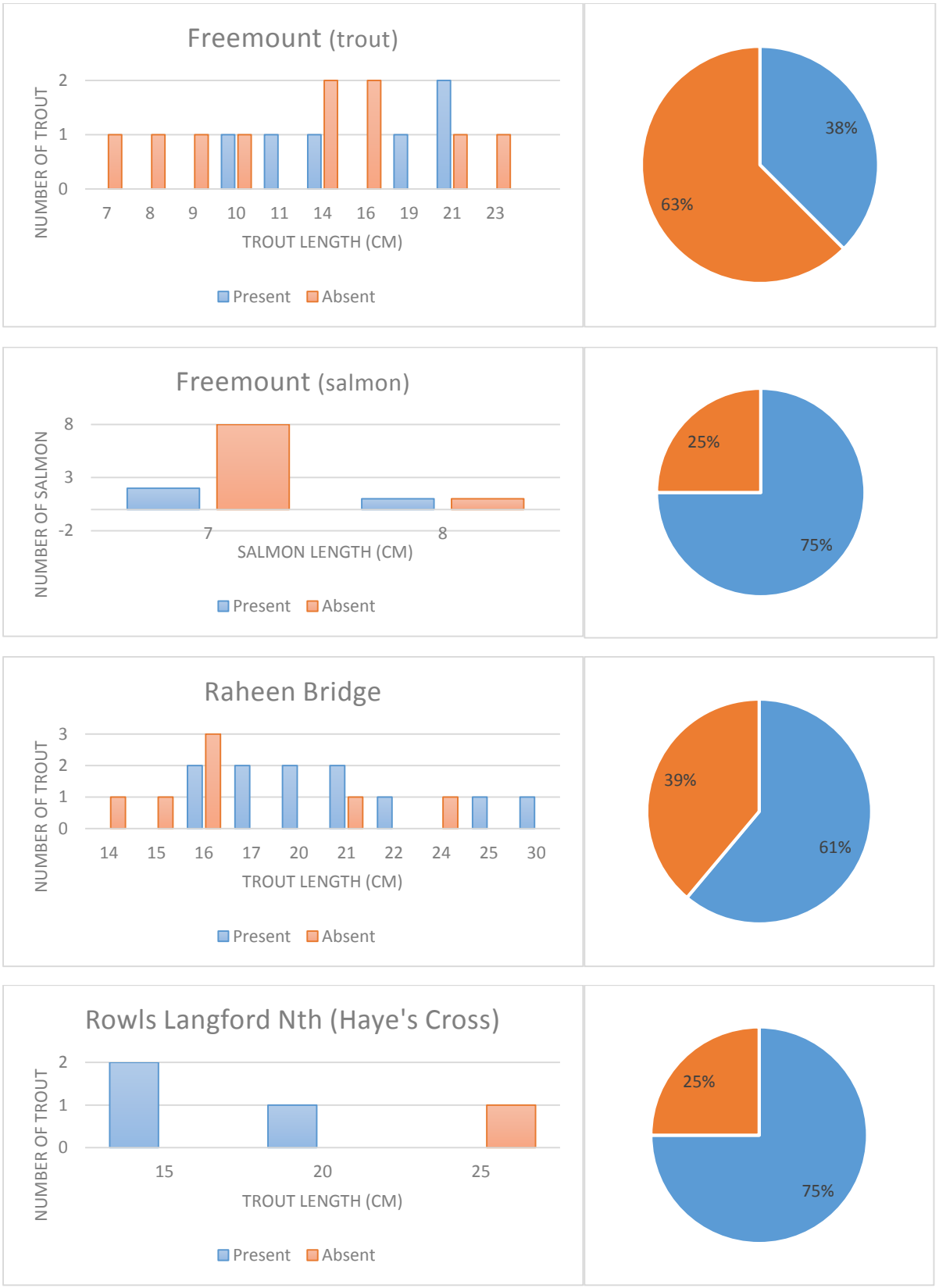

Figure 11 continued

Discussion

Twenty-three kilometres of river was surveyed with a total count of 17,609 individual FPM. This equates to approximately 0.13 FPM per metre of riverbed, or 130 FPM per kilometre. The majority of FPM were located in glide habitat (54%), followed by pool (21.6%) and riffle (12.8%). The FPM found in pools were typically on the edge of pools, rather than in the deeper section. As pools were located directly downstream of ripples, the FPM found in pools could have been deposited there during flood events.

The amount of silt deposited on the riverbed had a statistically significant effect on the distribution of FPM in the River Allow. Heavy and excessive levels of silt had lower means than the considerable, light and none groups. Even though the mean number of FPM was higher in areas with lower silt levels, most of FPM were counted in areas with heavy siltation, reflecting the high levels of silt currently entering the River Allow.

Bedrock was the only substrate that had a statistically significant difference in the mean number of FPM compared to other substrates (fines, gravel, cobble). On average, there were more mussels grouped together on bedrock, than on other substrates (except boulders). Research suggests that the preferred habitat for FPM in terms of substrate size is sand-patches stabilised by large stones (Skinner et al., 2003), with boulder sheltered mussel beds being critical after heavy floods because they provide protection (Vannote and Minshall, 1982). The majority of FPM were counted on cobble (57.7%) which probably reflects the predominantly cobble structure of the riverbed. However, the FPM's preference for larger boulders because they provide protection and stability might explain the high means recorded for the bedrock and boulder groups.

While statistical analysis found that FPM distribution in the River Allow is determined by factors such as siltation of the river bed and the type of substrate, point source discharges are also having an effect. Some surveyed sections of the River Allow were notable for the absence of live FPM. In particular, the surveys discovered that the water treatment plant at Freemount had not been functioning correctly and had been discharging flocculants into the river (Figures 8 and 10). Separate work on macroinvertebrate monitoring in the reach of river affected by the discharge found that the affected area was severely polluted. After IRD Duhallow raised the issue with Cork County Council, the local authority promptly pumped the flocculent out of the river. Thankfully follow up monitoring a year later discovered salmon had been spawning in

the affected area, however the FPM were still absent. IRD Duhallow LIFE have also responded to other industrial discharges further downstream, and there are no live FPM in the River Allow downstream of Kanturk town, which is the largest town on the River Allow.

Figure 8 Flocculent from the Freemount water treatment plant covering FPM

The presence of glochidia in all sites monitored in the Allow catchment is significant and points to FPM reproduction taking place. If Ireland is serious about protecting the FPM, then we must urgently address both point source pollution (e.g. industrial discharges), and diffuse pollution (e.g. agricultural, forestry, storm water runoff etc.) in all FPM rivers.

Conclusion

Twenty-three kilometres of river was surveyed with a total count of 17,609 individual FPM. Mussel distribution was influenced by the type of substrate, and degree of siltation. However, a number of incidents relating to industrial discharges are also having a significant impact of FPM population viability in the Allow.

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