An assessment of hydrological, hydrogeological and geomorphological conditions for the freshwater pearl mussel *Margaritifera margaritifera* for the potential translocation of mussels from Enniscorthy

Part 2 Low Flow Survey

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July 2018

1.0 Introduction

The freshwater pearl mussel (*Margaritifera margaritifera*) is endangered at a global scale and critically endangered in Europe and Ireland (Moorkens, 2011; Byrne et al., 2009). Populations of this species have undergone severe declines in recent years as a result of a combination of factors including catchment drainage, physical habitat degradation, nutrient enrichment, siltation and pollution.

The translocation of adult mussels is a last resort action, where mussels are present in a situation where they and their habitat are unlikely to survive. The direct movement of adult mussels has been demonstrated to be a high risk activity, thus interactions that increase the number of mussels with a new generation of juveniles and thus lower the risk of translocation are more desirable than moving adult mussels (Killeen & Moorkens, 2016). The method of gaining the added value of a new generation of juveniles, and thus more individuals to trial in different receptor sites, depends on a) the condition of the population and b) the potential for the survival of mussels in a different site.

This process can be undertaken in three ways, based on the condition of the river. Scenario 1 is where the mussel habitat has been restored over a wide area, in this case bankside encystment would provide the resource for potentially high numbers of juveniles to settle and could increase population numbers relatively quickly (Altmueller & Dettmer, 2006). Scenario 2 is where good mussel habitat has been restored in a small number of areas, or limited good habitat remains in the wild, here short term breeding can be used to produce large numbers of freshly excysted juvenile mussels to be placed in the best habitats (Moorkens, 2017a). Scenario 3 is where the river is slowly recovering but not yet to a stage to support young juvenile mussels, here longer term captive breeding can produce a new generation of young mussels to a stage where they no longer need to fully bury in the river bed substrate. These mussels should be used to supplement the remaining mussels in the best habitats where the native adult mussels remain extant.

The purpose of this study is to investigate the potential in the Slaney River to undertake Scenario 2, by investigating the potential for using short term breeding as part of a translocation exercise. In this case, the investigation is to determine the potential for remaining pockets of good juvenile habitat in the vicinity of Scarawalsh Bridge. These habitat pockets could be used to place short-term bred juvenile mussels, using the technique of Moorkens (2017a). A number of spot-checks were undertaken on the Lower River Slaney around Scarawalsh by Ecofact (2016). Live *Margaritifera* were confirmed to be present at Scarawalsh Bridge and also downstream of the N11 road bridge at the River Bann confluence. The Slaney at the River Bann confluence was checked by Moorkens in 2017 and found to be unsuitable for juvenile mussels.

The high flow survey was undertaken on 20th February 2018 and reported in Moorkens (2018). This informed more precisely the areas where the low flow survey should be undertaken. The low flow survey was undertaken on 3rd July 2018 by Evelyn Moorkens and Ian Killeen, under NPWS licences C136/2015 and C137/2015 respectively. Recent flows were very low, with data records showing 0.418 to 0.975m from the Scarawalsh Bridge gauge in the 5 weeks before the survey, and 0.422m on the day of the survey. The 95th percentile is 0.425m so this flow level was ideal for identifying the best places for potential permanent juvenile habitat.

The following requirements were outlined in the translocation proposal for the Enniscorthy mussels (Moorkens,2017b):

The nearest known site for *Margaritifera* in the Slaney River upstream of the proposed works is an area of preferential flow near Scarawalsh Bridge. Prior to any translocation, the following protocol for field study is proposed:

1. Use aerial photography to identify upstream and downstream limits for field studies.

2. A field study should be undertaken in two parts. Firstly, a **winter** high flow bank walkover should be undertaken to ensure the identified stretches do not have high flow constraints – highly drained and dirty inputs and / or chronic suspended solids issues can be clearly identified in these conditions, as can over deepened or bedrock restricted areas leading to excessively high flows. Caution should be taken as high flowing rivers are dangerous and a safe distance should be kept away from the water, which should not be entered during high flows.

3. The second field study should be undertaken during **summer** low flows, and an assessment should be made for river bed habitat suitability and quality, including:

   a. River bed habitat suitability for adults and juveniles – clast range, compaction, scour levels
   b. River bed habitat condition – algal and macrophyte levels (Refer to *Margaritifera* regulations 2009)
   c. Adult mussel numbers present
   d. Near-bed velocity (refer to Moorkens & Killeen, 2014)
   e. Redox potential (refer to Geist & Auerswald, 2007)
   f. Suitable receptor sites should be mapped carefully and photographed.

4. A hydrological, hydrogeological and geomorphological risk assessment of the local mini-catchments supporting the proposed translocation sites should then be undertaken to assess the resilience of the local catchment area in its role to protect against sediment and nutrient pollution, and against the exacerbation of drought conditions (particularly through artificial drainage of the upper mini-catchments), and its ability to protect the mussel population through appropriate detritus food production and delivery (sufficient connectivity of undrained land delivering positive juvenile mussel nourishment), and, where appropriate, the replenishment of stone of favourable clast sizes. This study is not constrained by season.

Parts 1, 2 and 4 above were undertaken and reported in Moorkens (2018). This report contains the results of Part 3 above, completing the investigations needed for the assessment of potential for translocation of juvenile and adult mussels.

2.0 Methodology

Three stretches of river were considered to be suitable for low flow investigation as follows (Figure 1):

- Reach A – Left side of island, where high flow is protected by small near-bank island – if low flow velocities are high enough
- Reach B – Top of the riffle area coming downstream towards the island – if river bed substrate is stable enough
- Reach C – Right hand channel along the length of the island – if enough of the flow follows this channel during low flows

Figure 1 Looking downstream from Scarawalsh Bridge showing the locations of the three reaches surveyed

A total of 10 1m^2 quadrats were compared. Each 1m^2 quadrat reflected the conditions in a potential receptor area of 3-5m^2. A total of 4 quadrats were examined at Reach A, 2 in Reach B and 4 in Reach C.

Measurements of velocity were taken in each potentially suitable quadrat. This was carried out using an OTT C2 Small Current Meter. Measurements were taken where the flow was not impeded by large boulders or dense weed. The full water depth was measured and then velocities were measured at near-bed level (i.e. 3 cm above the substrate surface), and at 60% depth (i.e 40% from the substrate surface) – the latter in accordance with widely used techniques for measuring river velocities. The equipment was set to measure over 50 seconds duration. The number of pulses in 50 seconds was then converted to ms^{-1} using the factors appropriate for the size of the propeller used. Ranking was achieved from highest to lowest velocity at both near bed and 60% velocities.

The redox potential was measured 4 times in each quadrat. The equipment comprises a 0.7m long probe fitted with a platinum tipped electrode, a reference potassium chloride electrode and a meter with a millivolt display. A reading is obtained by holding both electrodes in the water column until a stable open water reading is obtained. With the KCl electrode remaining in the water column, the platinum electrode is then inserted into the substrate to a depth of 5cm and a reading taken immediately. Ranking was achieved from lowest to highest in three parameters, mean redox, minimum redox and maximum redox loss from open water.

The habitat parameters considered were presence of adult mussels, dominant clast size (a wide range is best, presence of cobble with gravels and sands is good (>32mm), pebbles and large boulders less favourable(>16mm <32mm), presence of sands and gravels (good, moderate, none), presence of surface fine sediment (severe, moderate, light, none), presence of infiltrated fine sediment (silt plume: severe, moderate, light, none), evidence of scour and compaction (severe, moderate, slight, none), presence and severity of filamentous algae, diatom, macrophytes and bryophytes, category of juvenile habitat suitability (good, potential, none) and of habitat condition (good, moderate, poor). The presence or absence of juvenile food source was noted from riparian seepages (good, moderate, none), and ease of access was noted.

3.0 Results

Reach A

Reach A was located downstream of the first field on the left bank. It consists of a permanent fast flowing channel with high vegetation on both sides (Figure 2 and 3), although a considerable proportion of the left bank is covered with Himalayan balsam (*Impatiens glandulifera*). The shade reduces the level of algal and macrophyte growth, and the restricted size of the channel and its gradient supports good water velocities.

Figure 2. Reach A side channel during the high flow survey

Figure 3. View of the fast flowing side channel Reach A, downstream to upstream, during low flow survey.

The results from Reach A are given in Table 1, with habitat photos in Figures 4-7.

Table 1 Results from Reach A

Quadrat	A1	A2	A3	A4
GPS	S98474 44932	S98475 44933	S98464 44935	S98466 44939
Redox 1	173	197	190	184
Redox 2	186	191	201	194
Redox 3	180	190	183	178
Redox 4	185	206	208	206
Redox open water	230	244	250	245
Depth	23	20	25	17
Velocity NB	118	93	140	202
Velocity 60%	133	148	136	239
Mussels	0	0	0	0
Dominant clast	Wide range	Wide range	Wide range	Wide range
Sands and gravels	Good	Good	Good	Good
Silt surface	No	No	No	No
Silt infiltrated	Slight	Slight	Slight	Slight
Scour	None	None	None	None
Compaction	None	None	None	None
Filamentous algae	None	*Cladophera* Moderate	None	*Cladophera* Moderate
Diatom abundance	None	None	None	None
Macrophytes	*Ranunculus* Severe	None	None	*Ranunculus* Severe in parts
Bryophytes	None	None	None	None
Juvenile habitat suitability	Potential	Potential	Potential	Potential
Juvenile habitat condition	Moderate	Moderate	Moderate	Moderate
Juvenile food seepage	None	None	None	None
Ease of access	Moderate	Moderate	Moderate	Moderate
Habitat photo				

	
Figure 4 Reach A Quadrat 1	Figure 5 Reach A Quadrat 2
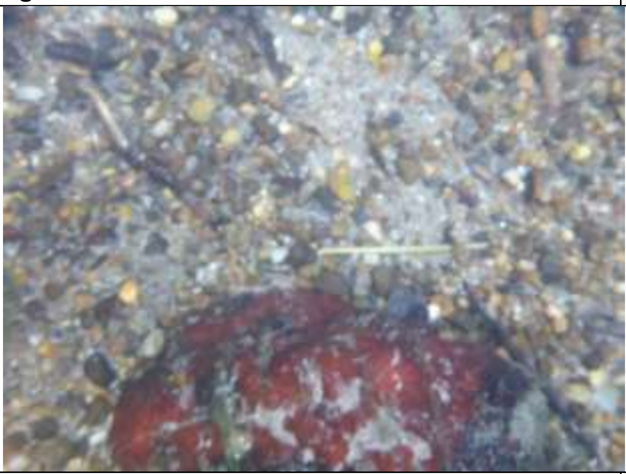	
Figure 6 Reach A Quadrat 3	Figure 7 Reach A Quadrat 4

Reach B

Reach B was located downstream of Scarawalsh Bridge and upstream of the large central island. It is in the central channel, at the top of a riffle that flows towards the right limb of the island (Figures 8 and 9). It consists of a permanent fast flowing channel with the riffle below creating a constant velocity, but above the most aggressive flow. There is no shade in this area.

Figure 8 Reach B area during high flow (arrow points to area)

Figure 9 Reach B area during low flow (arrow points to area)

Reach C

Reach C was located towards the right bank of the right hand channel along the length of the island (Figures 10 and 11). It consists of a permanent fast flowing channel edge, with stability at its best away from the central flow, and shade provided by the high tree lined banks in the field margin adjacent to the right bank of the river.

Figure 10 Reach C area during high flow

Figure 11 Reach C area during low flow (deeper, preferential flow towards right bank)

The results from Reach B and Reach C are given in Table 2, with habitat photos in Figures 12-17.

Table 2 Results from Reaches B and C.

Quadrat	B1	B2	C1	C2	C3	C4
GPS	S 98370 45027	S 98372 45029	S 98357 44983	S 98359 44987	S 98353 44983	S 98366 44989
Redox 1	80	200	193	197	190	184
Redox 2	193	189	181	191	201	194
Redox 3	189	192	193	190	183	178
Redox 4	179	175	188	206	208	206
Redox open water	235	235	240	240	240	240
Depth	42	42	235	20	19	20
Velocity NB	169	183	204	248	167	246
Velocity 60%	221	269	377	345	201	349
Mussels	0	0	0	0	0	0
Dominant clast	>32	>32	>64	>32	Wide range	Wide range
Sands and gravels	Moderate	Good	Good	Good	Good	Good
Silt surface	No	No	No	No	No	No
Silt infiltrated	Moderate	Moderate	Light	Light	Light	Light
Scour	Severe	Severe	None	None	None	None
Compaction	None	None	None	None	None	None
Filamentous algae	Severe	Severe	Light	Moderate	None	Moderate
Diatom abundance	None	None	None	None	None	None
Macrophytes	*Ranunculus* light	*Ranunculus* light	*Ranunculus* light	*Ranunculus* light	*Ranunculus* light	*Ranunculus* light
Bryophytes	None	None	None	None	None	None
Juvenile habitat suitability	No	No	Potential	Potential	Potential	Potential
Juvenile habitat condition	Poor	Poor	Moderate	Moderate	Moderate	Moderate
Juvenile food seepage	None	None	None	None	None	None
Ease of access	Good	Good	Good	Good	Good	Good

Photos of B and C habitats

Figure 12 Habitat B1

Figure 13 Habitat B2

Figure 14 Habitat C1

Figure 15 Habitat C2

Figure 16 Habitat C3

Figure 17 Habitat C4

The parameters of mean, minimum, and maximum redox were ranked from 1 to 10 based on the lowest loss being the best, and the parameters of near bed velocity and 60% velocity were converted to their values in metres per second and ranked from fastest to slowest. For all others, the parameters were ranked from 1-12, with an average ranking for sites with the same result. Mussel numbers, diatom, bryophytes, compaction, juvenile food seepage and surface silt were omitted, as there were none in any of the quadrats. Sands and gravels were not discriminatory as they were present throughout. Table 3 shows the ranking of the different quadrats for redox potential and flow velocity. Table 4 shows the ranking for the other parameters, and Table 5 shows the overall rankings for each site.

Table 3. Ranking of Redox and Flow

	%redox loss Mean	Rank	% redox loss min	Rank	% redox loss max	Rank	NBV	Rank	60% V	Rank
A1	19.75	2	16	2.5	22	1.5	118	9	133	10
A2	19.25	1	17	4.5	22	1.5	93	10	148	8
A3	21.5	5	20	9.5	23	3.5	140	8	136	9
A4	20.75	4	19	7.5	23	3.5	202	4	239	5
B1	22	7	17	4.5	24	5	169	6	221	6
B2	21.75	6	20	9.5	25	6	183	5	269	4
C1	19.75	3	15	1	26	7	204	3	377	1
C2	22.25	8	16	2.5	27	8	248	1	345	3
C3	23.5	9	19	7.5	28	9	167	7	201	7
C4	32	10	18	6	66	10	246	2	349	2

Table 4. Ranking of other parameters

Site	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4
Dominant clast	3.5	3.5	3.5	3.5	8	8	10	8	3.5	3.5
Silt infiltrated	4.5	4.5	4.5	4.5	9.5	9.5	4.5	4.5	4.5	4.5
Scour	4.5	4.5	4.5	4.5	9.5	9.5	4.5	4.5	4.5	4.5
Filamentous algae	2.5	6.5	2.5	6.5	9.5	9.5	2.5	6.5	2.5	6.5
Macrophytes	9.5	1.5	1.5	9.5	5.5	5.5	5.5	5.5	5.5	5.5
Juvenile habitat suitability	4.5	4.5	4.5	4.5	9.5	9.5	4.5	4.5	4.5	4.5
Juvenile habitat condition	4.5	4.5	4.5	4.5	9.5	9.5	4.5	4.5	4.5	4.5

Table 5. Total rankings

Site	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4
Sum of parameter rankings	58.5	54.5	60.5	61.5	89.5	91.5	51	60.5	69	63.5
Overall rank	3	2	4	6	9	10	1	5	8	7

4.0 Discussion

The results of the low flow survey have provided a ranking of the sites surveyed. Although the best sites in each reach were chosen for investigation, there were significant differences in the quality of the habitat parameters needed to sustain juvenile mussels.

The results show that even the best sites in Reach B would be inappropriate sites for juvenile augmentation, but Reaches A and C have some potential for the translocation of juveniles.

It is recommended that the best sites at Reach A (A1, A2 and A3, i.e. the downstream end of the section) should be used to create juvenile "nests" , i.e. protected pockets between cobbles should be excavated, cleaned, and enriched with juvenile gravels. The remaining sites and their surroundings in Reach A should be enriched by a thin spread of juvenile rich gravels to provide additional chances of juveniles finding appropriate micro-habitats in which to bury. Similarly, the best sites in Reach C (C1 and C2 at the upstream end of the island area) should also be prioritized for juvenile augmentation.

Although this survey highlights the areas with the best potential for juvenile augmentation and adult translocation success, the habitat is far from ideal. Although it has good physical river bed habitat, its condition is comparatively poor and the surrounding landuse is extremely intensive, with no seepages that would provide high quality juvenile food. Figures 18 – 21 show some of the pressures operating in the vicinity of the best potential augmentation areas. Immediately upstream of the bridge are large maize fields, and the field adjacent to the left bank of the river downstream of the bridge had little vegetation covering. The field adjacent to the right bank has intensive sheep grazing, with sheep accessing the river upstream of Reach C. In this area dry mounds of silty sand lie upstream of Reach C. The combination of nutrient application and bare soil is likely to reduce the likelihood of success for juvenile augmentation, although the physical habitat and river bed structure is very good.

Figure 18. Maize fields immediately upstream of Scarawalsh Bridge.

Figure 19. Reach A has very high turbidity when disturbed.

Figure 20. Bare soil and tanker abstraction of river water upstream of Reach A.

Figure 21. Banks of *Ranunculus* and bare mounds of dry sand upstream of Reach C.

In order to provide greater assurance of a net positive outcome following the translocation of mussels, it is recommended that short term breeding is also undertaken from a small sample of brooding Derreen mussels. One location in the Derreen River has good juvenile habitat in favourable condition and extensive wet grassland along its right bank. This section has been recommended to NPWS for juvenile short term breeding (See Figure 22 and 23). The following is an extract from the SAC monitoring report (Moorkens, 2015):

"*Small pockets of clean and more natural river bed habitat were found in the vicinity of Williamstown, where a small area of much less intensive land use combined with a good sloping section of river maintains faster flows and juvenile food. This is the only area that is likely to have medium term success with rehabilitation. It is not likely to be possible to reverse the intensification of the entire catchment to levels compatible with a sustainable Margaritifera population, but it may be possible to prevent total extinction through an incentive scheme to maintain the unimproved conditions where they exist near Williamstown, and potentially to augment the population through* *short term captive breeding and early release of juveniles into the best habitat areas, as has been demonstrated in the Nore River (Moorkens, 2014)*."

Figure 22. Adult mussels in an area of good juvenile habitat in the River Derreen.

Figure 23. The more natural surroundings of the Derreen River at Williamstown.

It must be understood that if all investigations at a site gave positive results, it is likely that a good population of *Margaritifera* would occur with juvenile mussels there already. However, where populations have had serious declines, the probability of brooding females encysting fish and of juvenile mussels falling into the remaining positive areas is very low. The balance of positive and negative results provide the best indication not only of which sites are likely to result in success, but also what sort of ongoing conservation management might best improve the location for sustainable juvenile survival over time. Although the chance of a successful adult translocation and of juvenile augmentation at Scarawalsh is low, it is worth trying. However, it is unlikely that the pressures on the river in this location could easily be lowered. The much greater chance of success would be in the Derreen River, where the river bed habitat and the riparian habitat could be managed. This would provide more confidence in predicting a successful positive outcome for mussels through the work of this project.

5.0 References

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