Condition Assessment for Northern Ireland's Freshwater Pearl Mussel *Margaritifera margaritifera* Population

This report should be cited as follows:

Horton, M., Bell, D., Keys, A. & Mitchell, F. (2018) Freshwater pearl mussel survey of Northern Ireland 2017. Report prepared by Ballinderry Rivers Trust for the Northern Ireland Environment Agency. Northern Ireland Environment Agency Research and Development Series No. XX/XX.

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Executive Summary

1. The freshwater pearl mussel *Margaritifera margaritifera* is a large, freshwater, bivalve mollusc, belonging to the Margaritiferidae family. It has a complex life-cycle which, combined with its long lifespan, makes it especially vulnerable to changes in its habitat and the wider environment (Wilson, 2011).
2. The aim of this survey was to assess the present condition of the freshwater pearl mussel population and its associated habitat condition on all six of the designated (SAC; ASSI, proposed ASSI) rivers in Northern Ireland.
3. The survey was undertaken in 2016 and 2017, following the protocol for population monitoring of freshwater pearl mussel *Margaritifera margaritifera* (Sime; 2015) in the 2015 Common Standards Monitoring (CSM) Guidance for Freshwater Fauna (JNCC, 2015).
4. In the defined survey sections on the three SAC rivers (Ballinderry, Owenkillew & Swanlinbar) a total of 13,210 freshwater pearl mussel were recorded. This is an increase of 263 individuals (+2.03% increase) on the 12,947 recorded during the previous survey (Reid *et al*., 2011).
5. In the defined survey sections on the three ASSI rivers (Owenreagh, Tempo & Waterfoot) a total of 11,186 freshwater pearl mussel were recorded. This is an increase of 2,154 (+23.85% increase) on the 9,032 recorded during the previous survey (Reid *et al*., 2011).
6. A total of 24,396 freshwater pearl mussels were recorded in the defined survey sections on six rivers throughout Northern Ireland, compared with 21,979 recorded in previous survey (Reid *et al.*, 2011). This is an increase of 2,417 (+11% increase) on the previous survey total.
7. Additional mussel surveys were carried out on the Ballinderry River and Owenkillew River. These additional surveys bring the total recorded, known, freshwater pearl mussel population in Northern Irelands SAC rivers up to 16,700 individuals.
8. The combined total recorded freshwater pearl mussel population in Northern Irelands rivers in this survey is 27,886 individuals.
9. The Owenkillew River SAC Condition status remained as Unfavourable – No Change.
10. The Swanlinbar River SAC Condition status was reclassified from No Change in the 2011 survey to Unfavourable – Declining.
11. The Upper Ballinderry River SAC Condition status was reclassified from No Change in the 2011 survey to Unfavourable – Declining.
12. The Owenreagh River ASSI Condition status remained as Unfavourable – No Change.
13. The Tempo River ASSI Condition status remained as Unfavourable – Declining.
14. The Waterfoot River ASSI Condition status remained as Unfavourable - No Change.
15. Water quality in all the SAC and ASSI rivers remained above maximum thresholds for good freshwater pearl mussel habitat, with Phosphate increasing at some sites since 2011.
16. All of Northern Ireland freshwater pearl mussel populations remain imperilled.
17. Catchment-scale water quality and habitat improvement works are required on all of Northern Ireland freshwater pearl mussel rivers to address on-going chemical water

quality issues, siltation of river substrate and direct impacts to mussel's survival, such as cattle trampling.

1. Introduction

The freshwater pearl mussel *Margaritifera margaritifera* is a large, freshwater, bivalve mollusc, belonging to the Margaritiferidae family. It is a very slow growing and long-lived creature, frequently living for more than 100 years, making it one of the longest living invertebrates on earth (Bauer, 1992). It has a complex life-cycle which, combined with its long lifespan, makes it especially vulnerable to changes in its habitat and the wider environment (Wilson, 2011).

Over the last 100 years, the species has undergone dramatic declines across its Holarctic range (Hastie & Cosgrove, 2001), including across the United Kingdom (Cosgrove *et al.*, 2000) and Ireland (Moorkens, 1999; Reid *et al.*, 2012). Consequently, the freshwater pearl mussel is listed as Endangered on the IUCN Red Data List (IUCN, 2008). In addition, it is listed on Annexes II and IV of the EC Habitats Directive (92/43/EEC) and Appendix II of the Bern Convention. In Northern Ireland, the species is further protected under the Wildlife (Northern Ireland) Order 1985 (as amended).

Once commonly found in many rivers in Northern Ireland (Beasley *et al*., 1998; Kerney, 1999), the freshwater pearl mussel is now found in only six rivers west of Lough Neagh (Wilson, 2011; Reid *et al.*, 2013) (Fig. 1) and recent modelling of distributional trends suggests that without intervention it may become extinct in the region by 2098 (Wilson and Roberts, 2011).

Of the six rivers in Northern Ireland known to still hold populations of freshwater pearl mussel (Fig. 1), three are designated Special Areas of Conservation (SAC) and Areas of Special Scientific Interest (ASSI), these being the Ballinderry, Owenkillew and Swalinbar (Claddagh) Rivers; a further one is designated an ASSI only, this being the Tempo River and remaining two are proposed ASSI's, these being the Owenreagh and Waterfoot Rivers.

Figure 1: Map showing the location of rivers in Northern Ireland with extant populations of freshwater pearl mussel (Wilson, 2011)

Condition assessment surveys for freshwater pearl mussel were carried out in 2004 by Environment and Heritage Service on the Ballinderry, Owenkillew and Swanlinbar Rivers, following designation as candidate SAC sites. After full adoption as SAC sites, Condition Assessments were carried out again by Killen (2007) and Reid *et al.* (2011).

Condition assessments on the Tempo River ASSI and Waterfoot River proposed ASSI were undertaken, for the first time in 2006 (Preston *et al.*, 2006). Both rivers were re-assessed as part of the 2011 Condition Assessment, which also included the Owenreagh River proposed ASSI, for the first time (Reid *et al.*, 2011).

The aim of the current survey was to assess the present condition of the freshwater pearl mussel population and its associated habitat condition on all six of the designated (SAC; ASSI, proposed ASSI) rivers in Northern Ireland.

2. Methodology

The survey was undertaken following the protocol for population monitoring of freshwater pearl mussel *Margaritifera margaritifera* (Sime; 2015) in the 2015 Common Standards Monitoring (CSM) Guidance for Freshwater Fauna (JNCC, 2015).

This protocol replaced the 2005 version of the CSM protocol for freshwater pearl mussel and made several previously discretionary assessment attributes mandatory (including Phosphorus, Nitrogen-Nitrate, BOD, Flow, Fine sediment (in substrate), Fine sediment (siltation), Filamentous algae, Fish host population density and Invasive alien species), as well as introducing a new mandatory attribute of Glochidia counts when appropriate.

The surveys were undertaken on the same mussel beds surveyed by Killeen (2007), Preston *et al.* (2006) and Reid *et al.* (2011).

In addition, further survey work was undertaken on the Ballinderry and Owenkillew Rivers to build a more comprehensive picture of the mussel populations in these SAC rivers.

Licensing and Consents

A Wildlife License, issued under the Wildlife (NI) Order 1985 and the Conservation (Natural Habitats etc) Regulations (NI) 1995, was obtained from DAERA Northern Ireland Environment Agency to survey for freshwater pearl mussel for scientific research/conservation purposes.

A Section 14 permit, issued under the Fisheries Act (NI) 1966, was obtained from DAERA Inland Fisheries to operate fishing gear (the electrofisher) in order to undertake host fish population and glochidia encystment assessment.

Population Assessment

Population density

Each mussel bed was surveyed using a standard bathyscope (Nuova rade Aquascope Jointed 335 x 510mm) - a perspex-bottomed viewing bucket, in wadable water (maximum depth of 1.2m).

Total counts of mussels were conducted within each discrete sub-population unit and their location recorded using a handheld GPS (Garmin etrex10).

Age Structure

In the Owenkillew River, four 1 x 50m transects were surveyed. As well as undertaking a total count along the 50m transect using a bathyscope, at the 10, 20, 30, 40 and 50m quadrates, loose substrate was removed from the 1x1m square and underlying gravel and sand disturbed allowing buried mussels to be revealed. All mussels, both visible and buried, in the 1x1m quadrate were collected, held in a bucket of river water and measured (length (mm)) before returning, along with the substrate, to the quadrate.

As per the JNCC (2015) protocol, age structure analysis was not undertaken in any other river due to the low densities of mussels.

Dead shells

Shells of dead mussels were collected from the sections of river bed surveyed and from the adjacent river banks. A size-frequency distribution analysis was undertaken for each site by measuring the total length (mm), along the longest axis, of each whole shell and half shell (one complete shell half, detached by the hinge from its other half). Where half shells were found to be within 0.1mm of another half shell from the same survey stretch, a precautionary approach was adopted whereby, assuming the two halves could be the shell of one mussel, the smaller of the two was discounted, to avoid possible artificial inflation of total number of individuals.

Water Quality

Chemical water quality data was obtained from the Northern Ireland Environment Agency's Water Management Unit for statutory monitoring points sited downstream of the survey units on each river. As in previous assessments (Killen, 2007; Reid *et al.* 2011) data for Soluble Reactive Phosphate, Nitrogen-Nitrate, Suspended Solids and BOD were obtained and covered the period January 2011 to December 2016.

Mean values were calculated for each parameter and temporal variance was plotted.

Condition Assessment thresholds values for each parameter as defined for Ireland (Moorkens, 2006) were applied (Table 1) as opposed the UK thresholds (Oliver, 2000), so that direct comparison with thresholds applied in previous population assessment (Killen, 2007; Reid *et al.* 2011) could be made.

Parameter	**Bauer (1988)** mg/l^{-1}	**Moorkens (*2006; ** unpublished)** mg/l^{-1}
Soluble Reactive Phosphate	<0.030	<0.005*
Nitrogen - Nitrate	<0.500	<0.125*
Suspended Solids†	<10.00	10.000*
BOD	<1.400	<1.000**

† Not required under the 2015 JNCC Protocol but assessed here for comparison with previous surveys. Thresholds obtained from the 2005 CSM for freshwater pearl mussel (JNCC, 2005)

Table: 1 Threshold values for four water chemistry parameters necessary for freshwater pearl mussel recruitment.

Flow

A qualitative assessment of flow was undertaken in the absence of representative flow data for each site. A desktop analysis of upstream abstraction and flow regulation structures was undertaken to determine potential impact on river regime.

Habitat Structure

A desktop and field-based qualitative assessment of habitat structure was undertaken for each site.

Substrate Quality

Fine Sediment (Redox)

Redox assessment (Geist and Auerswald, 2007) was undertaken to determine interstitial habitat quality at sites within each river surveyed. At each site a WTW pH 3110 conductivity/pH Meter with Schott Instruments reference potassium chloride electrode and nickel-tipped gravel probe, set to read conductivity in millivolts (mV), was used to obtain one open water reading and twenty readings at 5cm depth in the substrate. Mean µm for each site was used along with the Open Water mV reading to calculate a percentage loss of mV at 5cm depth in the substrate. Percentage loss in mV between open water readings and the substrate at 5cm depth was used as a proxy for percentage loss of dissolved oxygen between the two environments (Geist and Auerswald, 2007; Horton *et al*. 2014).

Filamentous algae

Percentage cover of filamentous algae within each section of river surveyed was estimated and noted.

Host Fish Population Assessment

Prior to this survey, host fish population assessments had never been undertaken as part of the previous Condition Assessments.

Suitable sites were chosen for each river based on salmonid habitat type, proximity to mussel beds and accessibility of sites.

Fully-quantitative, depletion sampling, electrofishing (Wyatt and Lacey, 1994) was undertaken at each site, using a Hans Grassl IG600L backpack electrofishing set to determine salmonid species assemblage and estimate the total host density. This method is consistent with the annual statutory monitoring procedure used by the Agri-Food and Biosciences Institute (AFBI) on behalf of Department of Agriculture, Environment and Rural Affairs' (DAERA) Inland Fisheries Group and Loughs Agency.

All fish captured were transferred to a holding bucket (one per electrofishing run) and the species and length (mm) of each fish was recorded. Age structure of the salmonid population was verified by constructing a length frequency distribution for each site.

Glochidia encystment

During the electrofishing survey at each site, the gills of each salmonid captured was inspected for glochidia. The number of fish identified as being infected with glochidia were recorded along with their species and length (mm).

Invasive species

At each site a riverbank walkover assessment was undertaken to determine the presence/absence of non-native invasive riparian plants and signs of American mink (*Neovison vison*).

Other attributes

Qualitative assessments of stocking transfers of other species, introduction/transfers of freshwater pearl mussel, pearl fishing and in-stream activities were undertaken at each site and recorded.

Condition assessment

In the previous assessments (Killeen, 2007; Reid *et al*., 2011) the conservation status of each river was determined using the Favourable Condition Table (Generic Attributes) set out in the JNCC Common Standards Monitoring Guidance for Freshwater fauna - Version August 2005.

In 2015, the Common Monitoring Standards were updated (JNCC, 2015), redefining the generic attributes of the Favourable Condition Table for freshwater pearl mussel and making some previously discretionary attributes for assessment mandatory.

The current conservation status of each river was determined using the 2015 version of the JNCC Common Standards Monitoring categories (Table 2) defining each by the attribute targets described by Sime (2015) (Table 3). The results were presented in a Favourable Condition Table for each river (Tables 8, 11, 16, 19, 23 and 26).

Favourable	**Unfavourable**
Maintained	Declining
Recovered	No change
	Recovering
	Partially destroyed (habitats)
	Totally destroyed (habitats)/lost from site

Table 2: Conservation Assessment for freshwater pearl mussel following the JNCC Common Standards Monitoring categories (JNCC, 2015).

Table 3: Favourable Condition Table (FCT) criteria used to assess the conservation status of the freshwater pearl mussel in Northern Ireland's rivers (extracted from JNCC 2015).

Attribute (* = discretionary)	**Target**	**Method of Assessment**	**Comments**
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Visual survey of riverbed	Population distribution should be close to that expected under near-natural conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations. The target is to secure a sustainable population of mussels that is able to utilise all naturally suitable habitat within the river.
b. Population density	≥ 5 mussels per m^2 within sample transects.	Visual survey of river bed.	The density data from all transects within each monitoring unit should be aggregated and the resulting figure assessed against the target. In smaller rivers where 50m transects have not been surveyed, density data from all quadrats should be aggregated and assessed against the target. (Note: Young *et al.* (2003) recommended a favourable condition target of 10 mussels per m^2 in UK rivers. This has been revised to 5, but locally agreed higher targets may be appropriate.)
c. Age structure	i. At least 20% of population ≤65mm ii. At least one mussel ≤30mm.	Length measurement of mussels recorded in quadrats within 50m transects.	Population profiles should not be attempted where mussel beds are vulnerable to damage. In this case, the target is to find at least one pearl mussel ≤65mm. This results in a lower degree of confidence that the population is reproductively viable but should protect it from potential adverse disturbance during survey. The target for mussels ≤30mm may be 5% at some sites (e.g. Northern Ireland) but, generally, is applied as a threshold of at least one mussel in order to confirm recent recruitment and minimise disturbance of a population during survey.
d. Dead shells	<1% of population per year and scattered distribution.	Counting within 50m transects.	1% (based on a 100 year life span) considered to be indicative of natural losses for survey sites and for the entire river population per year. Where >1% dead shells are found, an investigation into the cause should be carried out to assess whether it may be an exceptional natural event or an indication of an unnatural kill. The dead shells should be examined for freshness (by checking the colour of the nacre) to help assess the likelihood of a problem.
WATER QUALITY	See sub-attributes below.		

Attribute (* = discretionary)	**Target**	**Method of Assessment**	**Comments**
For freshwater pearl mussel, organic pollution, reactive phosphorus, acidification, and other nutrients are particularly important.	Generally, targets included in the CSM Guidance for Rivers should be used. These targets are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS) and diatoms, are applicable. However, depending on circumstance, UKTAG standards for HES under the WFD may be applicable. In addition to habitat-based targets, some more stringent targets for pearl mussel are listed below.	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Generally, water quality should not be injurious to any life stage. All classified reaches within the designated site that contain, or should contain, freshwater pearl mussel should comply with the targets given. Data from the last 3 years should be used. All water quality data should be available on request from the environment agencies.
a. Phosphorus	In locations where annual mean soluble reactive phosphorus (SRP) levels are <5 µg L^{-1}, the target should be 5 µg L^{-1}. For rivers that exceed this target a suggested target is the more stringent value of either: high status values for SRP under the WFD, or the SRP target for CSM river habitat.	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	The SRP target value should not be set for a river without first checking the baseline P levels and any historical data available for that river. Undetectable levels of SRP are not necessarily a guarantee of good health, particularly if the local analysis equipment is unable to perform at low concentrations. If all the available phosphorus is being transferred into filamentous algae then it will not be detectable as SRP in open water. A combination of very low SRP with the absence of filamentous algae is considered to indicate nutrient levels conducive to *Margaritifera* populations in favourable condition.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
b. Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Various thresholds of nitrate have been proposed in the literature with respect to Margaritifera: 0.5 mg L^{-1} N in central Europe (Bauer, 1988), 1 mg L^{-1} N for the UK (Oliver, 2000), 0.125 mg L^{-1} N for Ireland (Moorkens, 2006). Note, that one UK population with some recent recruitment has a median value of 0.338 mg L^{-1} N (Moorkens and Killeen, unpublished data). Like phosphorus, nitrate levels are a measure of the naturalness of the surrounding catchment, and limits should be set at those natural for that catchment. Where nutrient levels are too high to sustain pearl mussel populations, levels of all nutrients should be reduced until sustainability is achieved.
c. BOD	Mean BOD <1.0 mg L^{-1}	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Rivers with reproducing populations in the UK, Ireland and Spain have BOD levels consistently < 1.0 mg L^{-1} (Moorkens and Killeen, unpublished data). Elevated BOD (>1.4 mg L^{-1}) has been linked with poor juvenile survival in Central Europe (Bauer, 1988).
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	Gauging stations. (Data from environment agencies).	River flow affects a range of habitat factors of critical importance to freshwater pearl mussel, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and base flows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered.
HABITAT STRUCTURE In-channel structures and morphology	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of	Assess using CSM methods for river habitat or species-specific methods if available and appropriate.	The river's natural form and function should support all of the habitat features necessary for pearl mussels to thrive, in characteristic proportions. Widening or deepening of channels, and extensive artificial reinforcement of banks, are indicators of unfavourable condition. Further information on the importance of physical habitat to pearl mussels is available in draft CEN guidance. Information on in-channel structures is available in the CSM Guidance for Rivers.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
	the river. The comments column provides details of the importance of individual biotopes to freshwater pearl mussel.		
OTHER ATTRIBUTES			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Redox measurements collected in open water and river bed, at or around population transect locations.	Excessive delivery of fine sediment, from the catchment or artificially enhanced bank erosion, may lead to a range of problems relating to surface siltation, the compaction or concretion of river beds and to the in-filling of substrate interstices. This affects oxygen supply and exchange within the substrate as well as the ability of juvenile mussels to burrow. Infiltration by fine sediments is one of the main causes of decline in juvenile recruitment for pearl mussel populations. * The infiltration of high loads of fine sediment typically results in low oxygen supply to the interstices of the substrate. Redox measurements provide a reliable estimate as a surrogate for the oxygen level within the interstices of the substrate compared with the open water.
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Macroinvertebrate data collected and analysed by environment agencies.	PSI (Proportion of Sediment-sensitive Invertebrates) is an index developed to measure the impact of fine sediment on river-bed invertebrates (Extence *et al.,* 2013). It complements the methods suggested in the siltation section, although it is recommended as a more cost-effective, accurate and easily measurable target.
c. Filamentous algae	<5% cover across assessment units.	Visual assessment during mussel survey and relevant metrics collected during LEAFPACS survey by environment agencies.	Filamentous algal cover should be measured during the pearl mussel survey. In oligotrophic conditions nutrient levels should never be high enough to allow dense mats of filamentous algae to grow. The persistence of filamentous algae is an indication that nutrient levels may be too high for sustainable *Margaritifera* populations, but may also indicate low flow problems. Using the LEAFPACS method, with 3-5 sections per assessment unit surveyed depending on its size. More variable assessment units may require more surveys.
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2. 2. Should be able to find fish infected with glochidia between September and May.	Standard electrofishing protocols. Visual inspection of gills, particularly later in the glochidia incubation period.	An abundant supply of native juvenile salmonids is vital to the survival of the larval stage. The relative importance of salmon and migratory and non-migratory brown trout populations to pearl mussels will vary between rivers. Physical and chemical conditions need to be suitable for the well-being of all life stages of salmonids, including free access up the river and conditions in the estuary and lower river where the juveniles of migratory salmonids are present. It is important to determine the species of host fish that a mussel population needs in a particular river as local pearl mussel populations can use salmon, trout or both species. Electrofishing should be carried out twice using standard methods, once in early autumn to establish the presence and density of suitable fish hosts as a proportion of the fish

Attribute (* = discretionary)	Target	Method of Assessment	Comments
			population just downstream of mussel beds, and again in late spring to establish the presence of 1+ fish in the vicinity of permanent mussel habitat. This does not adversely affect pearl mussels. The fish in the second survey should be checked for encystment of glochidia on the gills, which are visible on the live fish. More detailed studies of fish numbers and glochidial encystment (e.g. number of glochidia per fish) can be undertaken but the above should be considered as a minimum requirement.
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	Survey data collected and analysed by the environment agencies.	Non-native species constitute a major threat to many river systems. Impacts may be on the river habitat itself (e.g. damage to banks and consequent siltation) or directly on characteristic biota (through predation, competition and disease), or a combination of these. Assessment of non-native species is based on the principles used in assessing high ecological status under the WFD, and applies to species on the banks and in the riparian zone as well as species of the channel and the margins. There is evidence that American signal crayfish may disturb freshwater pearl mussel, particularly juveniles (Gladman, 2012). Otherwise, refer to the WFD list of alien/locally absent species* (but not to be used exclusively). * http://www.wfduk.org/tagged/alien-species#. Note: This document includes a separate list of alien species for Ecoregion 17 (in which Northern Ireland lies); this list contains only high-impact species.
* f. Stocking transfers of other species	No inappropriate stocking/translocation of fish species.	Fishery stocking consents. Impact assessments of stocking consents on a catchment scale may be required to determine an acceptable level.	Rainbow trout and brook trout are resistant to glochidial infection and are not, therefore, suitable host species. Stocking of these species will create competition with native salmonids and is likely to reduce host opportunities for glochidia. Any stocking of native salmonids must take account of the genetic diversity of resident salmonids. The host fish/mussel relationship seems likely to have a genetic component, which could be affected by inappropriate stocking.
* g. Introduction/ transfers of freshwater pearl mussel	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	Knowledge of site management.	Translocation is not generally recommended as a conservation tool. It is a technique that has been little used, and must still be considered experimental. Translocation (if feasible) should therefore be seen as a last resort. In GB and Northern Ireland, genetically distinct freshwater pearl mussel populations have been found to exist in separate catchments (Cauwelier, 2009). Evolutionary Significant Units (ESUs) exist in GB between Scotland/northern England and NE Wales; and southern England and the remainder of Wales. It would be inappropriate to undertake translocations between these ESUs.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
			Any translocations or transfers of freshwater pearl mussels must follow IUCN and other local guidelines (e.g. Scotland Code for Conservation Translocations).
* h. Pearl fishing	No evidence of pearl fishing.	Standard survey protocol.	Pearl mussel fishing is prohibited throughout the UK.
* i. In-stream activities	No evidence of damage of existing mussel beds.	Environment agencies monitoring/ consenting programmes and standard survey protocol.	Engineering works that disturb river beds can be disastrous for mussel populations, so every effort needs to be made to leave them undisturbed. Other relevant activities include fishing (wading in the river) and canoeing (at access points to the river) particularly for vulnerable populations. As a minimum, existing areas should be safeguarded, whilst habitat lost through engineering works should be reinstated.

3. Results

Population Assessment

Populations in SAC Rivers

In the defined survey sections on the three SAC rivers (Ballinderry, Owenkillew & Swanlinbar) a total of 13,210 freshwater pearl mussel were recorded. This is an increase of 263 individuals (+2.03% increase) on the 12,947 recorded during the previous survey (Reid *et al*., 2011). This increase was despite survey Point transects B1-B8 on the Owenkillew River not being surveyed.

Populations in ASSI and proposed ASSI rivers

In the defined survey sections on the ASSI and proposed ASSI rivers (Owenreagh, Tempo & Waterfoot) a total of 11,186 freshwater pearl mussel were recorded. This is an increase of 2,154 (+23.85% increase) on the 9,032 recorded during the previous survey (Reid *et al*., 2011).

Conservation Status

A total of 24,396 freshwater pearl mussels were recorded in the defined survey sections on the six designated rivers throughout Northern Ireland, compared with 21,979 recorded in previous survey (Reid *et al.*, 2011). This is an increase of 2,417 (+11% increase) on the previous survey total.

Additional population assessment

Additional mussel surveys were carried out on the Ballinderry River and Owenkillew River.

On the Ballinderry River the entire 47-kilometre length of the bed of the river, from its source near Camlough to its mouth at Lough Neagh was surveyed, with the exception of a few unwadable stretches. A total of 1,468 mussels were recorded with the majority being in the upper reaches of the river. Only 35% of the mussel population are to be found in the defined SAC Condition Assessment monitoring sections (Section 16, 17 and 20-22) on the river.

On the Owenkillew River, the entire population of mussels in Survey Section 12 were counted. A total of 3854 mussels were recorded in the section with only 34% of the mussels occurring within the defined monitoring units (A-M) inside of Survey Section 12.

These additional surveys bring the total recorded, known, freshwater pearl mussel population in Northern Irelands SAC rivers up to 16,700 individuals.

Total Recorded Mussel Population in Northern Ireland's Rivers

The combined total recorded freshwater pearl mussel population in Northern Irelands rivers in this survey is 27,886 individuals.

4. Owenkillew River SAC

As in the previous assessments undertaken in 2004 (EHS), 2007 (Killen) and 2011 (Reid *et al.*), the 13 units (A-M) within Section 12 were surveyed, along with four 50 metre transects (T1-T4) (Fig. 2). In addition, 13 of and 21 point transects (A1-A13) were surveyed (Fig. 2).

The remaining eight point transects (B1-B8) were not assessed as it could not be ascertained at the time of survey, what the limit of each point transect was for a comparable survey to be undertaken.

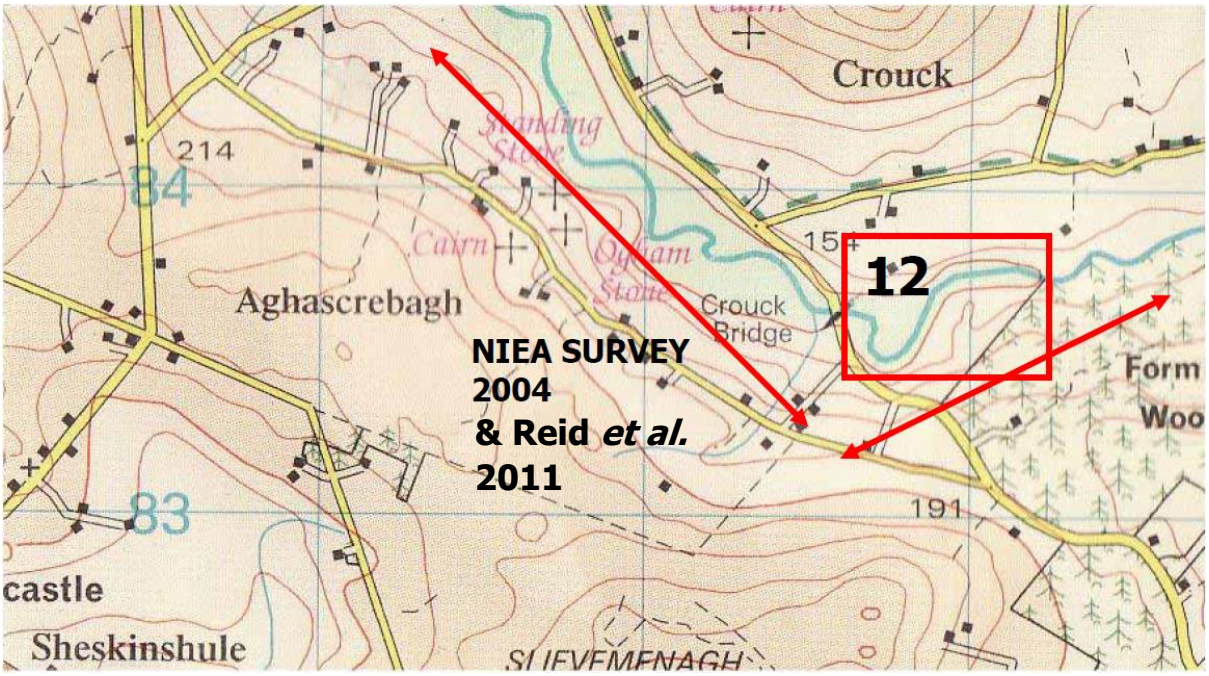


Figure 2: Map showing the survey sections on the Owenkillew River SAC, numbered to be consistent with previous surveys in 2004 (EHS), 2007 (Killen) and Reid *et al.* (2011) and red arrows indicating the extent of points and transects previously surveyed by NIEA (2004) and Reid *et al.* (2011) (Map source Reid *et al.* 2011)

In addition, a total mussel count was conducted in Section 12, representing the first comprehensive assessment of the mussel population in this section.

Population

A total of 8434 live mussels were observed (Table 4). This represents a +4.6% increase on the 8062 mussels observed in 2011 (Reid *et al.*), despite having not surveyed eight of the 21 point transects. This total also represents a +6.3% increase on the combined count of 7931 mussels reported in 2004 (EHS) and 2007 (Killen) surveys.

The spatial extent of the mussels was characteristically extensive beds of mussels with more than 100 individuals.

Section/ID	Description	No. of mussels			
		2004	2007	2011	2016
12	Upstream of Crouck Bridge		824	2,391	1,312
Points	21 points transects	6,380		5,467	6,640‡
Transects	Four 50 x 1m belt transects	727*		616†	743††
	Total	**7,931**		**8,062**^	**8,434**

* Killeen (2007) reported a count of 727 mussels from a four 50 x 1m belt transects and a mean river width of 3.74m yielding a total extrapolated estimate for that section of **2,719 mussels** (NIEA, 2004).

† Assuming a count of 616 mussels from four 50 x 1m belt transects and a mean river width of 3.74m yields a total extrapolated estimate for that section of **2,304 mussels** during 2011 (Reid *et al.,* 2011).

‡ On 13 (A1-A13) of and 21 point transects were surveyed. B1-B8 were not surveyed as it could not be ascertained at the time of survey, what the limit of each point transect was for a comparable survey to be undertaken

†† Assuming a count of 743 mussels from a four 50 x 1m belt transects and a mean river width of 3.74m yields a total extrapolated estimate for those sections of **2,779 mussels** during 2016.

^ Corrected Total - Reid *et al.* (2011) reported the total was 8,474 but had double counted 261 mussels at Point Transect A6 which falls inside survey Unit J on Survey Section 12.

Table 4: Number of live mussels observed in the Owenkillew River SAC survey sections in this survey and previous surveys.

A total of 743 mussels were observed in the four 50x1m belt transects (Table 5). This represents a +20.6% increase on the 616 mussels observed in 2011 (Reid *et al.*) and a +2.2% increase on the 727 mussels reported in 2004 (EHS).

Transect No.	No. of individuals		
	2004	2011	2016
T1	205	189	100
T2	451	374	566
T3	10	21	25
T4	61	32	52
Total	727	616	743

Table 5: Total number of mussels observed in four 50x1m belt transects (T1-T4) in the Owenkillew River SAC

Mussel densities in the transects were calculated as 2 individuals/m^2 in T1, 11.3 individuals/m^2 in T2, 0.5 individuals/m^2 in T3 and 1.04 individuals/m^2 in T4.

Length measurement of 98 live mussels were undertaken during the assessment of the four 50x1m belt transects (Fig. 3), ranging in size from 37 – 145mm. A total of 2 mussels measured were <65mm representing 2% of the transects' sample measured. No mussels <30mm were found.

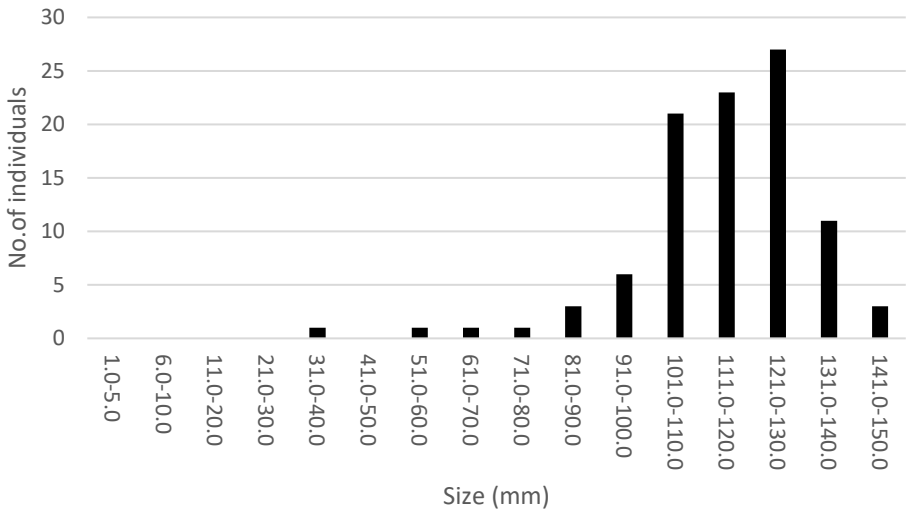


Figure 3: Size-frequency distribution of shell length (longest axis) of live mussels in four 50x1m belt transects (T1-T4) from the Owenkillew River SAC

Length measurements of 10 deceased mussels were taken during the assessment of the four 50x1m belt transects, ranging from 103 - 126mm. Size-frequency analysis of the shells (Fig. 4) shows that the mortality is largely confined to adult mussels that are most likely aged individuals. A further four mussels were found, but not measured, in T3 which appeared to have been crushed. Cattle were clearly accessing the river at this point and one cow was observed walking up the bed of the river.

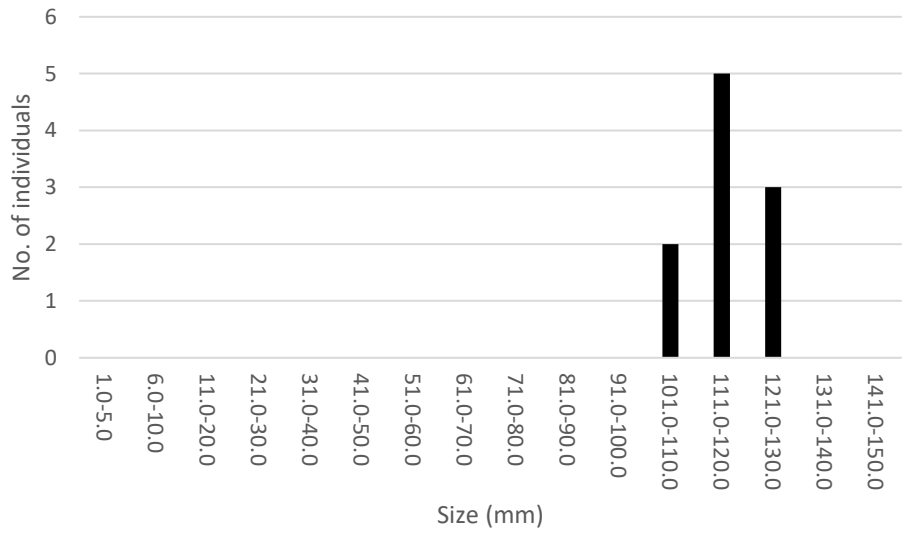


Figure 4: Size-frequency distribution of shell length (longest axis) of deceased mussels in four 50x1m belt transects (T1-T4) from the Owenkillew River SAC

A total of 30 shells were recovered from the entire length of Section 12, ranging in length from 55.9 – 135.1mm. Size-frequency analysis of the shells (Fig. 5) shows that the mortality is largely confined to adult mussels that are most likely aged individuals, however one mussel shell <65mm was recovered.

The recovery of this shell combined with the observed 2 live mussels <65mm, suggests that some recruitment has taken place in the last 10 years, albeit at very low numbers.

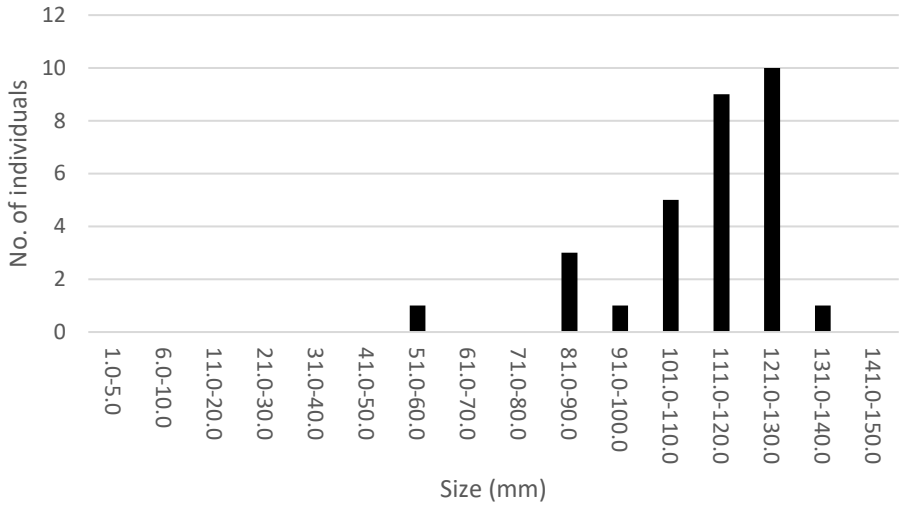


Figure 5: Size-frequency distribution of shell length (longest axis) of deceased mussels in Section 12 from the Owenkillew River SAC

In the comprehensive mussel count of Section 12, 3854 live mussels were observed at a density of 0.1 individuals/m^2.

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at Monanameal Bridge (H614 848), downstream upstream of Section 12.

The data obtained from NIEA covered the period January 2011 to December 2016 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 6) shows that phosphorus, nitrogen-nitrate and BOD were all above the target thresholds for freshwater pearl mussel (JNCC, 2015). Only suspended solids were generally lower than the threshold of 10mg/l, although on several occasions, during winter months, rose above this threshold at each site.

Constituent	Range	Mean
Phosphorus	0.01-0.09	0.02
Nitrogen-Nitrate	0.003-0.44	0.17
Suspended Solids	2.0-29.0	4.19
BOD	1.0-2.9	1.59

Table 6: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Upper Ballinderry River SAC (data obtained from NIEA Water Management Unit)

Flow

There are no flow regulation structures upstream, of Section 12.

Habitat Structure

Throughout the survey sections, bed material consists of a good mix of gravel/pebble/cobble with pebble and cobble dominant. In sections the river is interspersed with boulders creating dynamic flow paths across and down the channel.

Good quality spawning, nursery and holding habitat for salmonids were present with the pool-riffle sequence largely in tacked.

Riverbank and corridor habitat are characteristically extensive stretches of rough pasture and improved grassland grazing, with sporadic trees comprising mostly willow, alder and rowan. Formill Wood, a commercial conifer planation, flanks the southern bank of the river at the upstream extent of T3 and T4 belt transects and several of the point transect survey sites.

The river support diverse populations of benthic macro-invertebrates, macrophytes, freshwater pearl mussel and salmonids (brown trout and Atlantic salmon).

Fine sediment (redox)

Redox assessment was carried out in units B, G, J and L of Sections 12 (Table 7). Redox potential differences between open water and interstitial water at 5cm depth were greater than 20% (range 37-39%).

Redox potential differences had decreased slightly since the survey in 2006 (Killen) but could not be assessed against the 2011 survey (Reid *et al.*) as redox was measured.

Unit	Location	% loss at 5cm		
		2007	2011	2016
B	62645 83632	43	not assessed	39
G	62804 83550	not assessed	not assessed	37
J	62831 83586	39	not assessed	37
L	-	45	not assessed	39

Table 7: Redox potential measurements at sites in the Owenkillew River SAC during the 2006 (Killen), 2011 (Reid *et al.*) and 2016 surveys

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >5% throughout the survey sites.

Fish host population assessment

Atlantic salmon are the preferred host in the Owenkillew River, confirmed through gill inspection for glochidia encystment in this survey.

Electrofishing was undertaken at Monanameal Bridge (H 6146 8467). A 20-metre length of river was fished, upstream of Monanameal Bridge, with an average channel width of 12 metres; the area fished was therefore 240m^2. In total, 192 salmonids were captured comprising 172 salmon and 20 trout of various age classes.

Size-frequency analysis of the salmon population (Fig. 6) revealed that all 175 of the salmon were 0+ and 1+ age classes resulting in a density of 0.73 salmon/m^2.

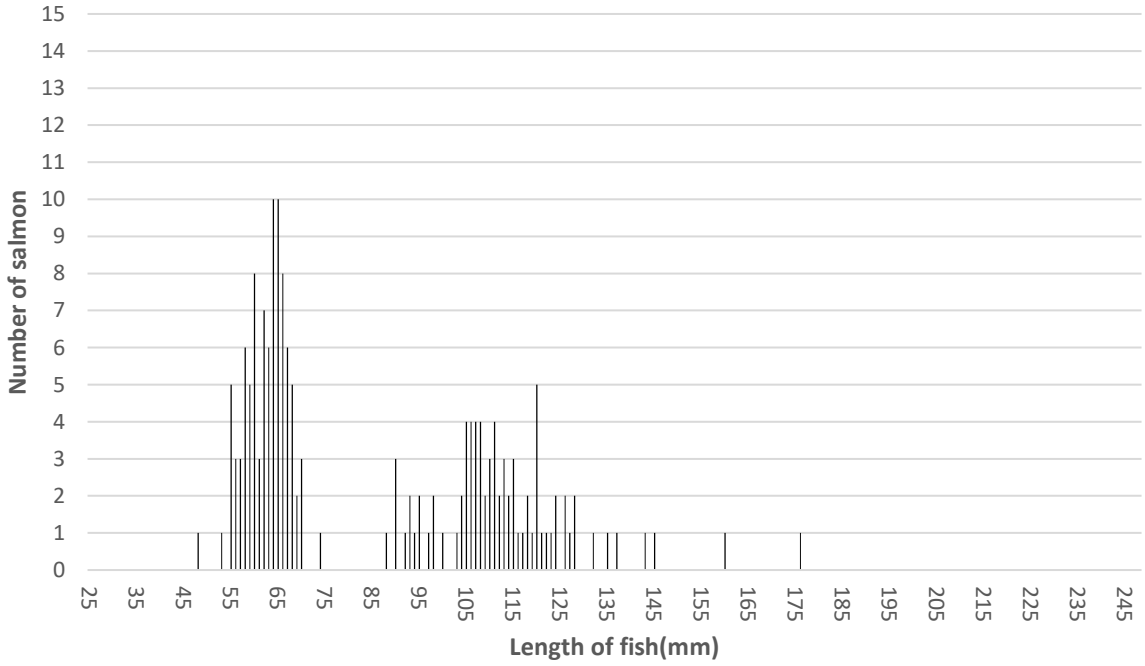


Figure 6: Size-frequency distribution of Atlantic salmon caught at Monanameal Bridge (H6146 8467) on the Owenkillew River SAC

Glochidia infection assessment

Of the 175 salmon captured during electrofishing, 104 were infected with glochidia (Fig. 7). This represents a 59.4% infection rate of available host salmonids in the electrofished stretch. Glochidia infection rates were high, typically 50-100 glochidia per fish. Both 0+ and 1+ year class fish were infected.

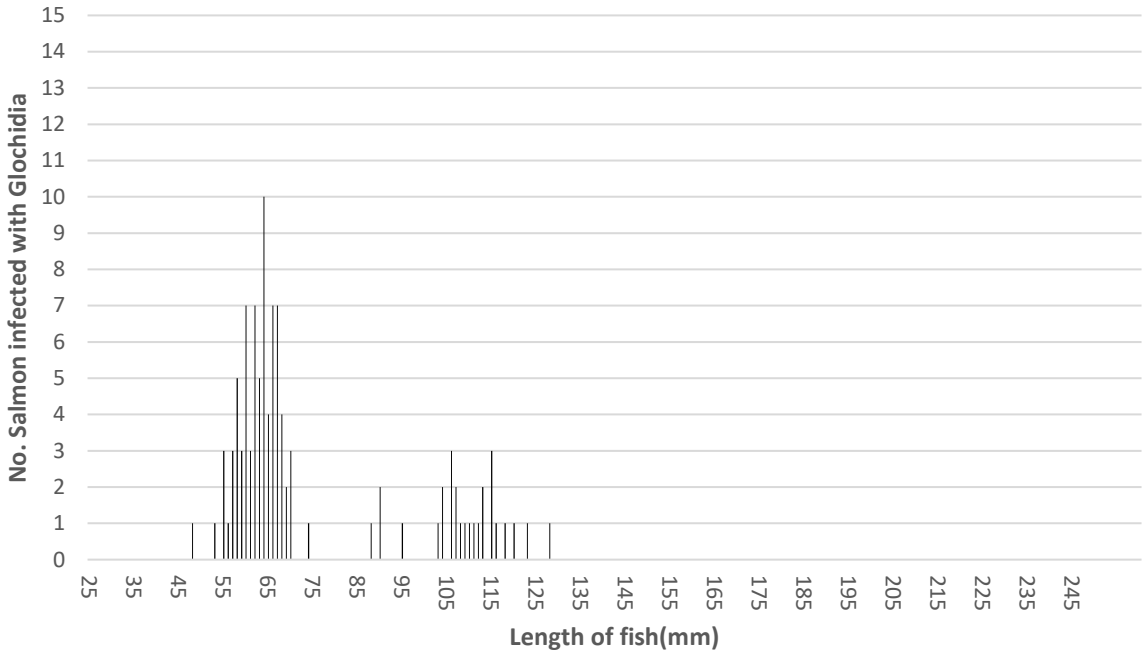


Figure 7: Size-frequency distribution of Atlantic salmon infected with glochidia caught at Monanameal Bridge (H6146 8467) on the Owenkillew River SAC

Alien/locally non-native species

No non-native invasive species were noted during the surveys.

Stocking transfers of other species

No stock transfers of other species are known to have taken place.

Introduction/transfer of freshwater pearl mussel

No introduction or transfer of freshwater pearl mussel have taken place.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the SAC.

In-stream activities

A lot of the fields lining the SAC are not fenced off to exclude livestock. As a result cattle can access the rivers at many points. Typically, one bank fenced whilst the opposite one is not or has the remnants of an old fence.

The cattle urinate and excrete in the river adding to the excess nutrient problem as well as causing trampling of banks leading to siltation. There was evidence of direct mussel

trampling by cattle at two locations in the SAC. Freshly dead mussels were found upstream of both Monanameal Bridge and Crouck Bridge at livestock drinking points.

The Owenkillew Community Development Company have created a development plan for the area, which includes the erection of riverside fencing and closing off of livestock watering points. If this project is deployed it would have great benefit to the mussel population in the Owenkillew.

There were no signs of river drainage in the surveyed sections.

Table 8: Conservation Assessment for the Owenkillew SAC freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Extensive beds of mussels with more than 100 individuals but areas of suitable habitat in-between with few or no mussels	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	T1 - 2 individuals/m^2 T2 - 11.3 individuals/m^2 T3 - 0.5 individuals/m^2 T4 and 1.04 individuals/m^2 **AVERAGE – 3.72 individuals/m^2** **ABUNDANCE CODE - C**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	2% (2 individuals)	i. FAIL
	ii. At least one mussel ≤30mm.	None	ii. FAIL
d. Dead shells	<1% of population per year and scattered distribution.	44 dead, 8434 living (0.5%)	PASS
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.02 mg L^{-1} (range 0.01-0.09)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	0.17 mg L^{-1} (range 0.003-0.44)	FAIL
BOD	Mean BOD <1.0 mg L^{-1}	1.59 mg L^{-1} (range 1.0-2.9)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally	No impediment to flow upstream	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Range 37-39%	FAIL
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	<5% cover across assessment units.	PASS
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.73 salmon/m^2	PASS
	2. Should be able to find fish infected with glochidia between September and May.	175 (59.4%) of salmon were infected with glochidia	PASS
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	None	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	None	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	None	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS
*** i. In-stream activities**	No evidence of damage of existing mussel beds.	Cattle trampling of river banks; mussels trampled by cattle	FAIL
OVERALL CONDITION: UNFAVOURABLE - NO CHANGE			

5. Swanlinbar (Cladagh) River SAC

The four sections on the Swanlinbar (Cladagh) River SAC previously surveyed in 2007 (Killen) and 2011 (Reid *et al.*) were assessed (Fig. 8).

Figure 8: Map showing the survey sections on the Swanlinbar (Cladagh) River SAC, numbered to be consistent with previous surveys in 2007 (Killen) and 2011 (Reid *et al.*). (Map source Reid *et al.* 2011).

Population

In the survey sections, a total of 3995 live mussels were observed (Table 9). This represents a 10.15% increase on the 3627 mussels reported in 2011 and a 20.73% increase on the 3309 mussels reported in 2007. The spatial extent of the mussels was characteristically dispersed extant beds of less than 100 individuals.

Section	Location	No. of mussels		
		2007	2011	2016
[redacted]				

Table 9: Number of live mussels observed in the Swanlinbar (Cladagh) River SAC survey Sections in this survey and previous surveys.

No length measurement of live mussels was undertaken due to the low density of the population.

A total of 471 shells were recovered from the four survey sections of the SAC, ranging in length from 58.4 – 125.9mm. This is an increase of 324.32% on the 111 shells collected during the 2011 (Reid *et al.*) survey.

Size-frequency analysis of the shells (Fig. 9) suggests that the population is comprised largely of adults, and therefore aging, mussels; noted in the previous survey (Reid *et al*, 2011). Two shells <65mm length were recovered (range 58.4-60.5mm) suggesting there is some mortality of juveniles in the mussel beds. No shells <30mm were recovered.

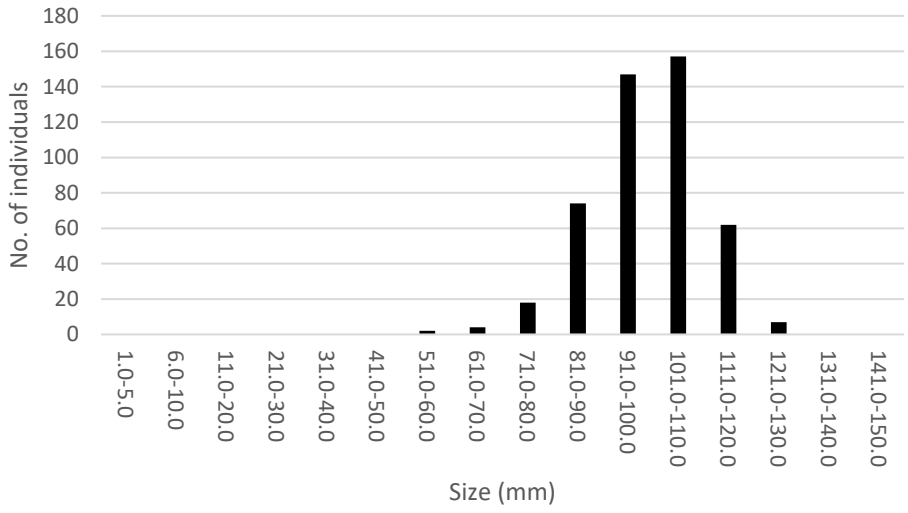


Figure 9: Size-frequency distribution of shell length (longest axis) of deceased mussels (empty shells) from the Swanlinbar (Cladagh) River SAC

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at Thompson's Bridge (H253 313) which is located ~3km downstream of the survey sites.

The data obtained from NIEA covered the period January 2011 to March 2017 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 9) shows that phosphorus, nitrogen-nitrate and BOD were all above the target thresholds for freshwater pearl mussel (JNCC, 2015). Only suspended solids were generally lower than the threshold of 10mg/l, although on several occasions rose above this threshold. These exceedance events are common autumn, winter and early spring.

Constituent	Range	Mean
Phosphorus	0.01-0.05	0.02
Nitrogen-Nitrate	0.10-0.65	0.27
Suspended Solids	2.00-25.0	4.92
BOD	1.00-3.30	1.70

Table 9: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Swanlinbar (Cladagh) River SAC (data obtained from NIEA Water Management Unit)

Flow

There are no weirs/ artificial barriers or major abstraction points present upstream of the survey sections.

Habitat Structure

Throughout the survey sections there was a mixture of sand/gravel/pebble and cobble.

Certain sections had good quality spawning, nursery and holding habitat. Section 3 below Glassdrumman Bridge had a good nursery habitat for juvenile salmonid habitat and thus this section was chosen to electrofish to determine fish density and glochidia infection rates.

Some mussel beds were found in good numbers in deep holes and slow moving water with a lot of silt upstream of Glassdrumman Bridge. This habitat isn't the best mussel habitat suggesting the mussels have been deposited here during floods.

There has been no drainage works carried out on the surveyed sections.

The majority of riverbank along the survey sections was tree lined with a mixture of improved and unimproved grassland.

Fine sediment (redox)

Redox assessment was carried out in Sections 2, 3 and 5 (Table 10). Redox potential differences between open water and interstitial water at 5cm depth were greater than 20% (range 38-59%).

Redox potential differences had decreased at sites 2, 3 and 5 since the survey in 2006 (Killen) but had increased in the Owengarr tributary, near its confluence with the Swanlinbar River. This was consistent with observed deposition of sediment on the riverbed substrate.

The results could not be assessed against the 2011 survey (Reid *et al.*) as redox was measured.

Section	Location	% loss at 5cm			
		2007	2009	2011	2016
5	Bed 1	54	52	not assessed	39
5	Bed 2	50	-	not assessed	
4	Bed 7	56	-	not assessed	not assessed
4	Bed 6	27	-	not assessed	not assessed
4	Bed 5	46	46	not assessed	not assessed
3	Bed 10 d/s of confluence with Owengarr tributary	44	-	not assessed	38
	Owengarr tributary near confluence with Swanlinbar	56	-	not assessed	59
2	u/s Owengarr confluence	47	48		38
2	u/s part	53			38

Table 10: Redox potential measurements at sites in the Swanlinbar (Cladagh) River SAC during the 2007 (Killen), 2011 (Reid *et al.*) and 2016 surveys

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >10% in slower velocity areas but in faster flowing stretches was <5%.

Fish host population assessment

During this survey, both Atlantic salmon and trout were found to be hosts for freshwater pearl mussel in the Swanlinbar (Cladagh) River. This survey is the first to report this finding and was confirmed through electrofishing and gill inspection for glochidia encystment.

Electrofishing was undertaken at Clontelaghan. A 33-metre length of river was fished, upstream of (H2206 2867), with an average channel width of 13 metres; the area fished was therefore 429m^2. A total of 50 salmonids were captured comprising 23 trout and 27 salmon of various age classes.

Size-frequency analysis of the Atlantic salmon population (Fig. 10a) revealed that all 27 of the salmon caught were 0+ and 1+ age classes resulting in a density of 0.06 salmon/m^2.

Size-frequency analysis of the trout population (Fig. 10b) revealed that all 23 of the trout were 0+ and 1+ age classes resulting in a density of 0.05 trout/m^2.

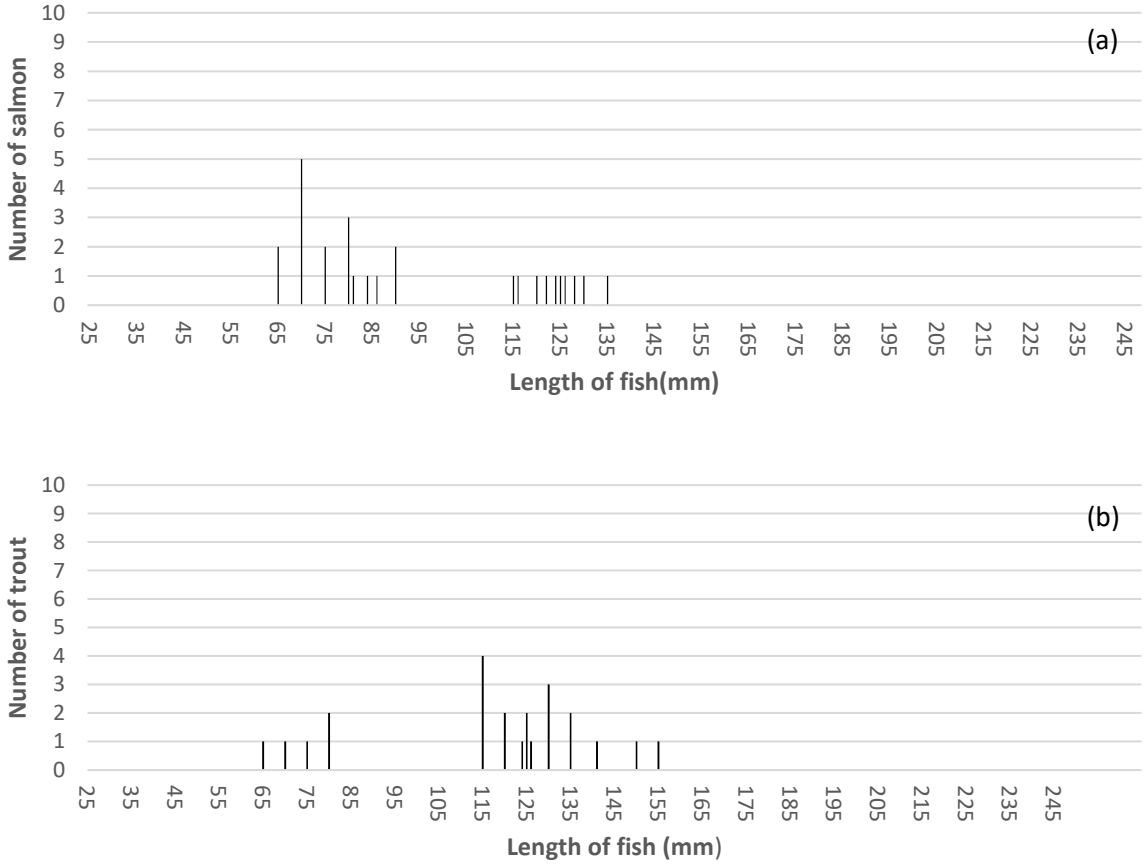


Figure 10: Size-frequency distribution of (a) Atlantic salmon and (b) trout caught at Clontelaghan (H2206 2867) on the Swanlinbar (Cladagh) River SAC

As both trout and salmon are suitable as hosts, the combined total of trout and salmon (50 salmonids) provided a host fish density of 0.12 salmonids/m^2.

Glochidia infection assessment

Of the 50 trout and salmonids captured during electrofishing, 8 salmonids (5 trout and 3 salmon) were infected with glochidia (Fig. 11). This represents a 16% infection rate of available host salmonids in the electrofished stretch. Glochidia infection rates were relatively low, typically 10-20 glochidia per fish. Both 0+ and 1+ year class fish were infected.

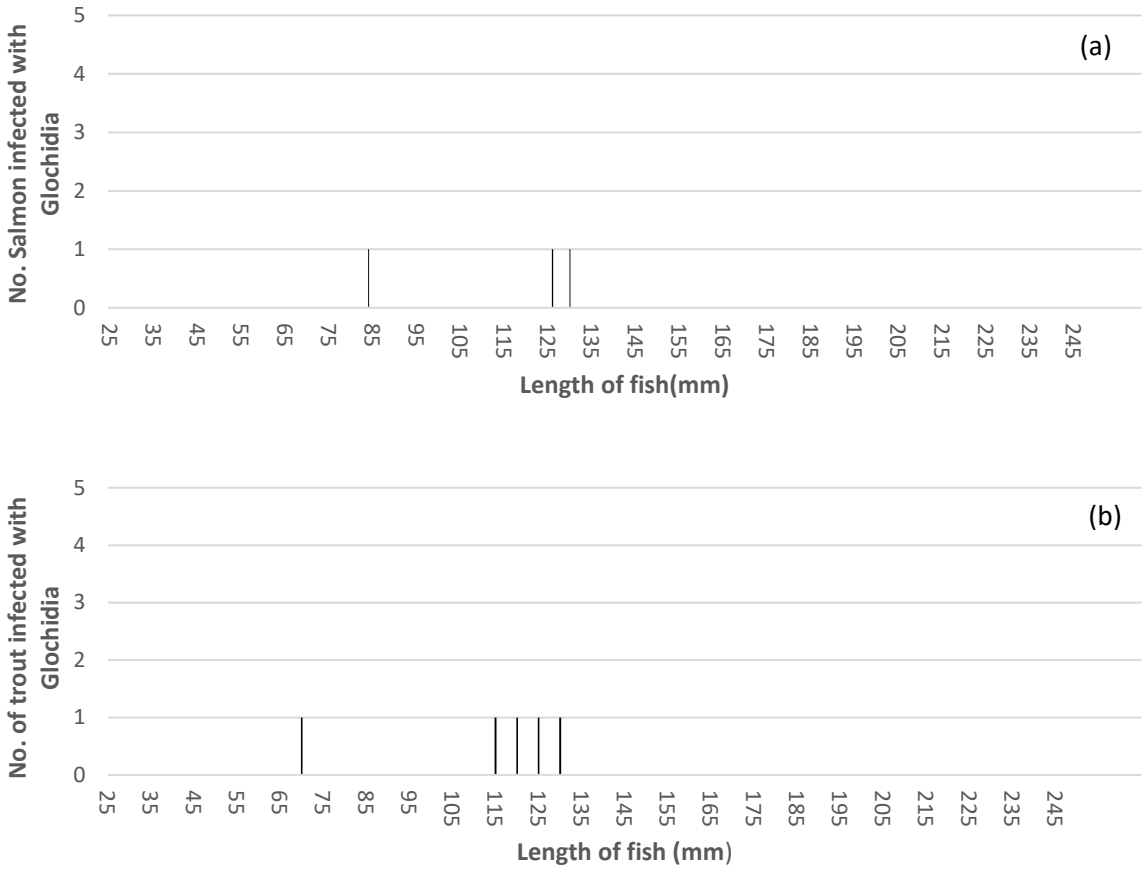


Figure 11: Size-frequency distribution of (a) salmon and (b) trout infected with glochidia caught at Clontelaghan (H2206 2867) on the Swanlinbar (Cladagh) River SAC

Alien/locally non-native species

No non-native invasive species were noted during the surveys.

Stocking transfers of other species

Trout were stocked here for a short period in the late 1990's/early 2000's from the Marlbank Hatchery at Florence Court through the Erne & Melvin Enhancement Company (EMEC), however no recent stocking of fish has been undertaken.

Introduction/transfer of freshwater pearl mussel

No introduction or transfer of freshwater pearl mussel have taken place.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the SAC.

In-stream activities

There were no signs of damage to the riverbed or banks during the survey period.

The majority of banks along the survey sections seemed to be stable with the majority fenced to exclude cattle. However, along with a few cattle watering points there is a ford H227 288 where farm machinery and cattle cross the river.

During the time of the survey, mussels were dying at an alarming rate. Hundreds of mussel shells were found throughout sections 4a, 4b and 5. The shells were in a clean condition, suggesting that the mussels hadn't long perished and a lot of them were found randomly throughout the channel. There had been no significant rainfall or floods in the weeks prior to the survey so the distribution of dead shells suggest that the mussels had died where they werfound as opposed washed up on banks or gravel shores as is typically seen after flooding.

Many moribund mussels where found on their sides on the river bed. The Swanlinbar mussels where in great distress during this survey whilst invertebrate and salmonid populations seemed to be healthy and White-clawed crayfish were found also, so there was no obvious reason to explain the high mortality of Swanlinbar mussels.

Table 11: Conservation Assessment for the Swanlinbar SAC freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Extant beds of mussels with less than 100 individuals.	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	Transects not assessed to due to vulnerability of population. 3995 live mussels observed (+10.15% increase in numbers on the previous assessment in 2011) **Estimated average – 0.19 mussels/m^2**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	None	FAIL
	ii. At least one mussel ≤30mm.	None	FAIL
d. Dead shells	<1% of population per year and scattered distribution.	471 dead, 3995 living (11.9%)	FAIL
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.02 mg L^{-1} (range 0.01-0.05)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	0.27 mg L^{-1} (range 0.10-0.65)	FAIL
BOD	Mean BOD <1.0 mg L^{-1}	1.70 mg L^{-1} (range 1.0-3.3)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree	No impediment to flow upstream	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Range 38-59%	FAIL
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	5-10% cover across assessment units.	FAIL
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.12 salmonids/m^2 (Both trout and salmon are suitable hosts)	PASS
	2. Should be able to find fish infected with glochidia between September and May.	8 (16%) of salmonids were infected with glochidia	PASS
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	None	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	No recent hatchery fish releases	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	None	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS
*** i. In-stream activities**	No evidence of damage of existing mussel beds.	On obvious evidence of damage of existing mussel beds.	PASS
OVERALL CONDITION: UNFAVOURABLE – DECLINING (from No Change (2011))			

6. Upper Ballinderry River SAC

The three sections on the Upper Ballinderry River SAC previously surveyed in 2007 (Killen) and 2011 (Reid *et al.*) were assessed (Fig. 12).

Figure 12: Map showing the survey sections on the Upper Ballinderry River SAC, numbered to be consistent with previous surveys in 2007 (Killen) and 2011 (Reid *et al.*) (map source Reid *et al.* 2011).

In addition, a total mussel count was conducted along the entire Upper Ballinderry River SAC and lower Ballinderry River representing the first comprehensive assessment of the mussel population in the Ballinderry River.

Population

In the survey sections, a total of 520 live mussels were observed (Table 12). This represents a -38.53% decrease on the 846 mussels reported in 2011 and a -47.42% decrease on the 989 mussels reported in 2007. The spatial extent of the mussels was charactaristically dispersed extant beds of less than 100 individuals.

Section	Location	No. of mussels		
		2007	2011	2016

Table 12: Number of live mussels observed in the Upper Ballinderry River SAC survey Sections in this survey and previous surveys.

No length measurement of live mussels was undertaken due to the low density of the population.

During 2016 and 2017, Ballinderry Rivers Trust conducted a full bed survey for freshwater pearl mussel of the entire Upper Ballinderry River SAC and wadable stretches of the lower Ballinderry River. In total, 1225 wild mussels were observed in the Upper Ballinderry River SAC and 23 in the lower Ballinderry River. This represents the first compressive assessment of wild freshwater pearl mussel numbers in the Ballinderry River system.

A total of 154 shells were recovered from the entire 24 km length of the SAC, ranging in length from 72.8 – 134.0mm. Size-frequency analysis of the shells (Fig. 13) suggests that the population is comprised largely of adults, and therefore aging, mussels; noted in the previous survey (Reid *et al*, 2011). No shells <65mm length were recovered.

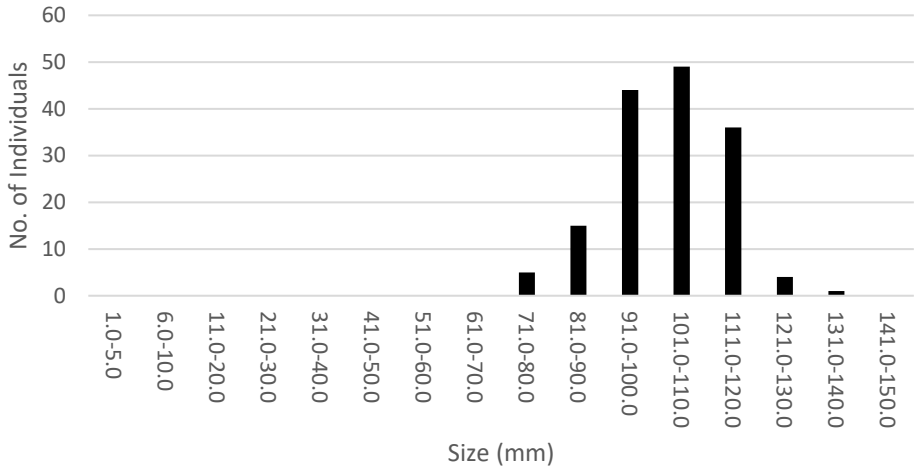


Figure 13: Size-frequency distribution of shell length (longest axis) of deceased mussels (empty shells) from the entire (24km) Upper Ballinderry River SAC

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at two sampling points in the SAC:

1. Corkhill Bridge (H734793) – upstream point of Section 16
2. King's Bridge (H812 765) – near the downstream limit of the SAC and downstream of all survey sections.

The data obtained from NIEA covered the period January 2013 to March 2017 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 14) shows that phosphorus, nitrogen-nitrate and BOD were all above the target thresholds for freshwater pearl mussel (JNCC, 2015). Only suspended solids were generally lower than the threshold of 10mg/l, although on several occasions rose above this threshold at each site.

Constituent	Range	Mean
Phosphorus	0.01-0.12	0.04
Nitrogen-Nitrate	0.29-2.04	1.2
Suspended Solids	0.29-2.04	1.2
BOD	1.0-6.4	2.0

Table 14: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Upper Ballinderry River SAC (data obtained from NIEA Water Management Unit)

Flow

There are no flow regulation structures upstream, of Section 16. Wellbrook weir, belonging to The National Trust's Wellbrook Beetling Mill is located in the middle of Section 17. Water is diverted, via a millrace, to turn a waterwheel for demonstration purposes only. The waterwheel is in operation infrequently and for short periods of time (~5 minutes per demonstration).

Bells Rock, a shallow waterfall, is located in upper Kildress at (H765 786), downstream of Sections 16 and 17 but upstream of Section 21-22.

Upper Kildress weir (H766 786) and Lower Kildress weir (H773 784) are located downstream of Section 17 but upstream of Section 21-22. Water is diverted from Upper Kildress weir to a commercial fish farm. A ~250-metre section of river below the weir is often dewatered during periods of low to moderate flow and as such can not support freshwater pearl mussel or host salmonids.

Water is no longer diverted from the river at Lower Kildress weir, water simply passes over the weir crest.

Habitat Structure

Throughout the survey sections, bed material consists of a good mix of sand/gravel/pebble/cobble and in sections is interspersed with boulders creating dynamic flow paths across and down the channel.

Good quality spawning, nursery and holding habitat for salmonids were present with the pool-riffle sequence largely in tacked.

There has been no drainage works carried out in the survey sections, so the channel retains its natural form, except where water is impounded behind Wellbrook Weir where the water is unnaturally deep.

Riverbank and corridor habitat are characteristically extensive stretches of mixed native woodland with some improved grassland grazing.

The river in these sections can support diverse populations of benthic macro-invertebrates, macrophytes, freshwater pearl mussel and salmonids (dollaghan trout, brown trout and

Atlantic salmon); as well as other water-dependant species such as European eel, otter, daubenton's bat, kingfisher (pers. obs. Ballinderry Rivers Trust).

Fine sediment (redox)

Redox assessment was carried out in Sections 16 and 21-22 (Table 15). Redox potential differences between open water and interstitial water at 5cm depth were greater than 20% (range 24-42%).

Redox potential differences had decreased since the survey in 2006 (Killen) but could not be assessed against the 2011 survey (Reid *et al.*) as redox was measured.

Section	Location	% loss at 5cm		
		2007	2011	2016
22	u/s Aughlish Bdg	43	not assessed	38-42
21	H77856 78342	43	not assessed	38
17	d/s Wellbrook Bdg (silt bar)	44	not assessed	not assessed
17	d/s Wellbrook Bdg (gravel bar)	26	not assessed	not assessed
16a	50m u/s confluence of Cloughfin Tributary	33	not assessed	24
16b	Silty transects	44	not assessed	not assessed
16c	d/s end of box at confluence with Cloughfin	20	not assessed	30

Table 15: Redox potential measurements at sites in the Upper Ballinderry River SAC during the 2007 (Killen), 2011 (Reid *et al.*) and 2016 surveys

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >10% in slower velocity areas but in faster flowing stretches was <5%.

Fish host population assessment

Trout are the preferred host in the Ballinderry River, confirmed through electrofishing and gill inspection for glochidia encystment (Ballinderry Rivers Trust) and through encystment experimentation at Ballinderry Rivers Trust's conservation breeding centre (Strachen *et al*, in press).

Electrofishing was undertaken at Henry's farm Bridge (H758 791). A 28-metre length of river was fished, upstream of Henry's Farm Bridge, with an average channel width of 14 metres; the area fished was therefore 392m^2. 176 salmonids were captured comprising 142 trout and 32 salmon of various age classes.

Size-frequency analysis of the trout population (Fig. 14) revealed that 100 of the trout were 0+ and 1+ age classes resulting in a density of 0.26 trout/m^2.

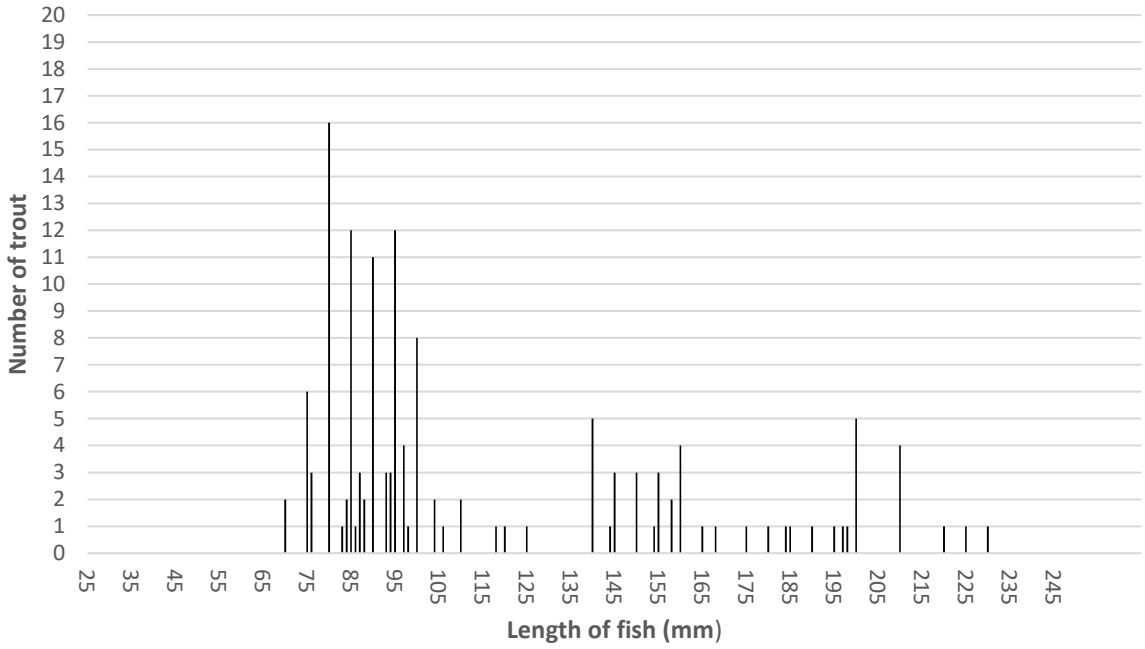


Figure 14: Size-frequency distribution of trout caught at Henry's Farm Bridge (H 758 791) on the Upper Ballinderry River SAC

Glochidia infection assessment

Of the 142 trout captured during electrofishing, 39 were infected with glochidia (Fig. 15). This represents a 27.5% infection rate of available host salmonids in the electrofished stretch. Infection was not limited to 0+ and 1+ trout, with some larger trout also being infected (Fig. 15). Glochidia infection rates were relatively low, typically 10-20 glochidia per fish. Both 0+ and 1+ year class fish were infected. It is also possible that some of the larger fish could have been 3+ year class.

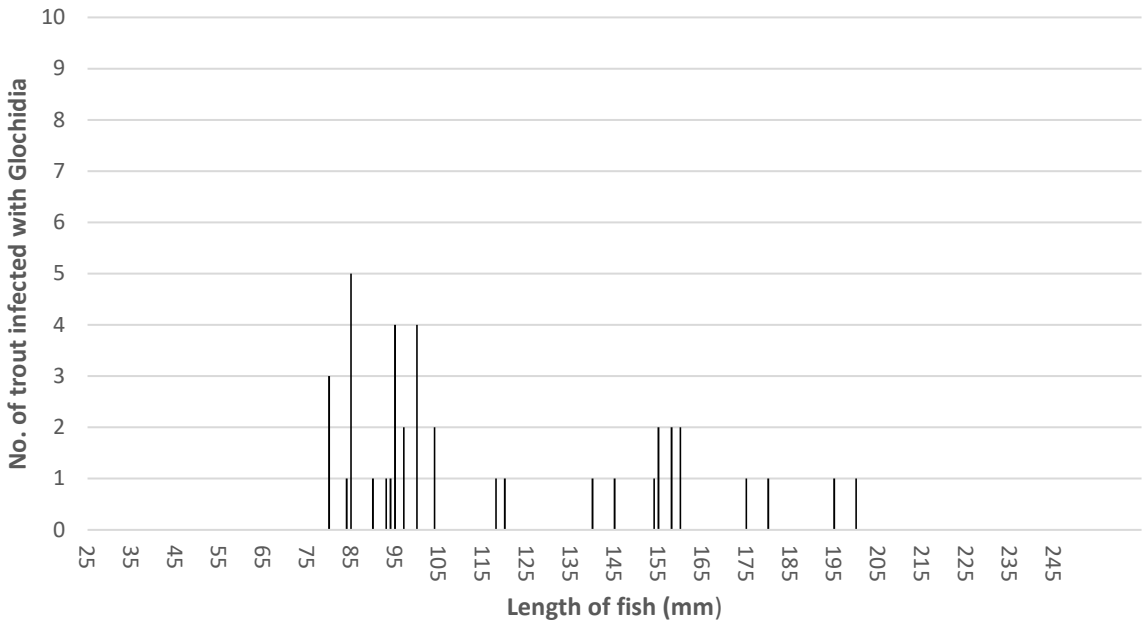


Figure 15: Size-frequency distribution of trout infected with glochidia caught at Henry's Farm Bridge (H 758 791) on the Upper Ballinderry River SAC

Alien/locally non-native species

No non-native invasive species were noted during the surveys; however, the following is known:

1. Japanese knotweed *Fallopia japonica* occurs in the Upper Ballinderry SAC above the survey stretches. At the last assessment of infestation extent undertaken in June 2018 there was approximately 250m^2 of Japanese Knotweed growing at 20 site locations, ranging in size from 1m^2 to 200m^2 (Ballinderry Rivers Trust, 2018 *unpublished*)
2. Farmed Rainbow trout *Oncorhynchus mykiss* have escaped in low numbers to the Ballinderry River, between Sections 17 and 21-22 from the commercial fish farm at Kildress (*pers. comm.* Ballinderry Rivers Trust)
3. American Mink *Neovison vison* are present at Section 21-22 (*pers. obs.* Ballinderry Rivers Trust)

Stocking transfers of other species

As stated above, rainbow trout *Oncorhynchus mykiss* are known to have escaped from the fish farm on occasion.

Captive-bred trout bred at Ballinderry Rivers Trust's Conservation Breeding Centre have been released along this stretch in the past. These trout are bred from wild brood stock and are native to the river. They are released carrying glochidia on their gills for conservation purposes.

Introduction/transfer of freshwater pearl mussel

Ballinderry Rivers Trust (previously Ballinderry Fish Hatchery Ltd) have been running a breeding programme for Ballinderry freshwater pearl mussel since 1999.

In 2010, 101 captive-bred juvenile mussels were released at two locations in Survey Section 17.

In 2014, a further 210 captive-bred juvenile mussels were released throughout the lower stretch of Survey Section 16.

Following this survey, in 2017, funded by NIEA, the Trust has undertaken the largest reintroduction of freshwater pearl mussel ever taken, releasing 1993 captive-bred juveniles, ranging in size from 3-8cm, into Survey Section 17.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the SAC.

In-stream activities

The stretch has undergone an extensive fencing programme, run by Ballinderry Rivers Trust and funded by the Heritage Lottery Fund (2012-15), to reduce livestock access to the river and banks. Almost all open livestock waterpoints on the main channel have been closed off and replaced with in-field pasture pumps. Bank stabilisation works were also carried out in where erosion was severe.

As a result, there is little cattle trampling of banks or bank slippages caused by high-flow events impacting on unstable banks.

Arterial drainage does still occur in some of the tributary rivers of the Upper Ballinderry River SAC.

There is excessive siltation of mussel habitat in survey section 20-22 at the mouth of the Tirmacshane tributary (H756 792), with 30-50cm of silt in places. The source of the silt is being investigated by NIEA.

Since the last survey in 2011, non-consented in-channel activities have occurred in the upper reaches of the SAC at Barony Road/Boundary Bridge (A505) at H656 791 and in the Kinnagillian tributary (H660 801) which has resulted in damage to mussel habitat due to the removal of bed habitat for mussels and salmonids at the site of impact and excessive siltation of the bed further downstream.

Table 16: Conservation Assessment for the Ballinderry SAC freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Extant beds of mussels with less than 100 individuals.	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	Transects not assessed to due to vulnerability of population. 520 live mussels observed (-38.53% decrease in numbers on the previous assessment in 2011) **Estimated average – 0.03 mussels/m^2**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	None	FAIL
	ii. At least one mussel ≤30mm.	None	FAIL
d. Dead shells	<1% of population per year and scattered distribution.	154 dead, 1225 living (12.57%) of entire river population	FAIL
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.04 mg L^{-1} (range 0.01-0.12)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	1.2 mg L^{-1} (range 0.29-2.04)	FAIL
BOD	Mean BOD <1.0 mg L^{-1}	2.0 mg L^{-1} (range 1.0-6.4)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole	Flow impediment structures throughout survey stretch. Dewatering of channel between survey sections 17 and 21-22	FAIL

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Range 24-42%	FAIL
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	5-10% cover across assessment units.	FAIL
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.26 trout/m^2	PASS
	2. Should be able to find fish infected with glochidia between September and May.	39 (27.5%) of trout were infected with glochidia	PASS
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	Japanese knotweed in places upstream of survey sections. Low numbers of escapee Rainbow trout reported in stretch. American Mink present but with no severe impact on host fish density or mussels	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	Recent releases hatchery-reared native trout carrying glochidia	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	Introductions agreed to be in the best interests of the population	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
* i. In-stream activities	No evidence of damage of existing mussel beds.	Excessive siltation of mussel habitat in survey section 20-22. Further impacts known on mussel beds upstream	FAIL
OVERALL CONDITION: UNFAVOURABLE – DECLINING (from No Change (2011))			

7. Owenreagh River proposed ASSI

The fifteen sections on the Owenreagh River proposed ASSI previously surveyed in 2011 (Reid *et al.*) were assessed (Fig. 16).

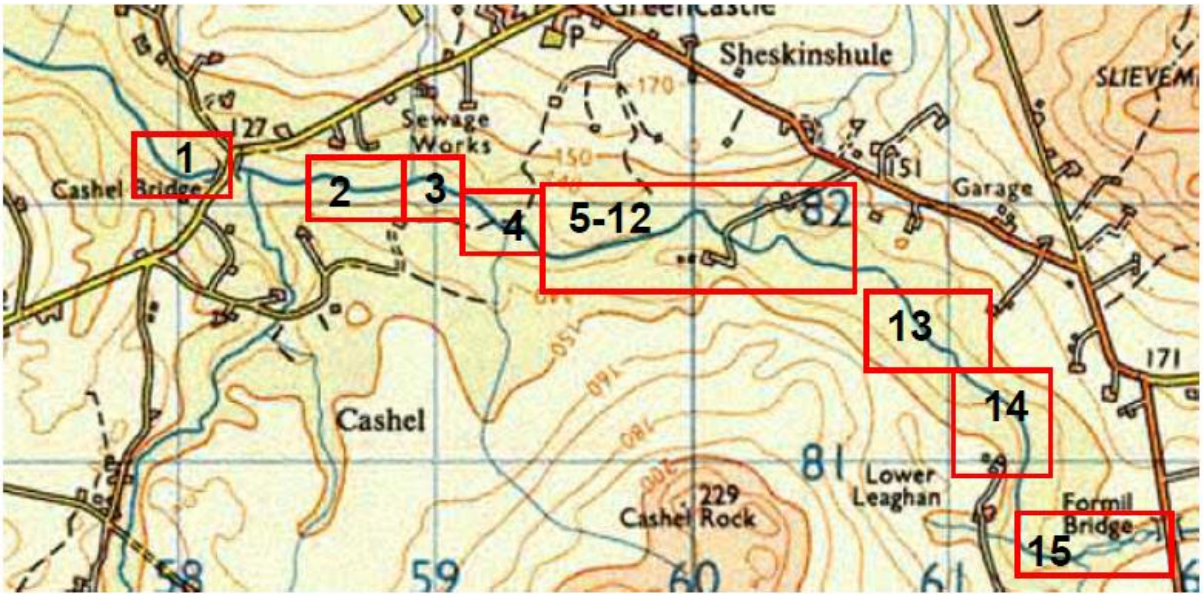


Figure 16: Map showing the survey sections on the Owenreagh River ASSI, numbered to be consistent with previous survey in 2011 (Reid *et al.*). (Map source Reid *et al.* 2011)

Population

In the survey sections, a total of 9750 live mussels were observed (Table 16). This represents an 18.97 % increase on the 8195 mussels reported in 2011. The spatial extent of the mussels was characteristically dense beds of more than 100 individuals.

Section	No. of mussels	
	2011	**2017**
1	2	0
2	0	0
3	50	171
4	773	1012
5	926	1211
6	1007	554
7	10	25
8	364	418
9	601	1240
10	1676	3415
11	1100	432
12	1100	809
13	353	372
14	233	91
15	0	0
Total	**8195**	**9750**

Table 16: Number of live mussels observed in the Owenreagh River proposed ASSI survey Sections in this survey and previous survey in 2011 (Reid *et al.*).

No length measurement of live mussels was undertaken due to the low density of the population.

A total of 24 shells were recovered from the 15 survey sections of the ASSI, ranging in length from 91.49 – 129.55mm. This is a decrease of -59.3% on the 59 shells collected during the 2011 (Reid *et al.*) survey.

Size-frequency analysis of the shells (Fig. 17) suggests that the population is comprised largely of adults, and therefore aging, mussels; noted in the previous survey (Reid *et al*, 2011). No shells <65mm length were recovered.

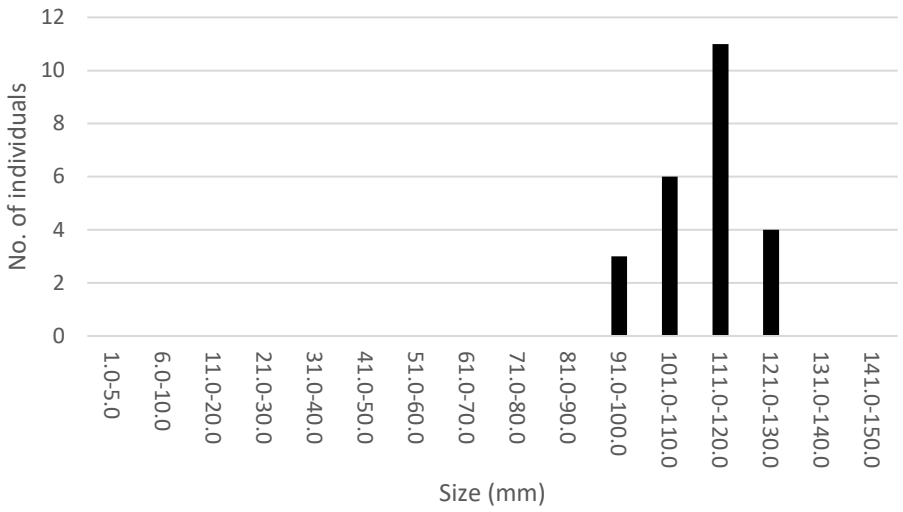


Figure 17: Size-frequency distribution of shell length (longest axis) of deceased mussels (empty shells) from the Owenreagh River proposed ASSI

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at Drumlea (H535 859) which is located downstream of the survey sites.

The data obtained from NIEA covered the period January 2011 to March 2017 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 17) shows that phosphorus and BOD were all above the target thresholds for freshwater pearl mussel (JNCC, 2015). Nitrogen-nitrate and suspended solids were generally lower than the threshold of 0.125mg/l and 10mg/l respectively, although on several occasions rose above this threshold. These exceedance events are common autumn, winter and early spring.

Constituent	Range	Mean
Phosphorus	0.01-0.07	0.010
Nitrogen-Nitrate	0.08-0.76	0.035
Suspended Solids	2.00-66.0	4.900
BOD	1.00-3.20	1.530

Table 17: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Owenreagh River proposed ASSI (data obtained from NIEA Water Management Unit)

Flow

There are no flow regulation structures upstream, of the survey sections.

Habitat Structure

The Owereagh bed material consisted of a mix of sand/gravel/pebble with less cobble and large stones compared to the neighbouring Owenkillew. There are a few deep, silted bends upstream of the farm Bridge below Cashel Rock that had pearl mussel beds, other than this the river was more natural with a mix of good spawning, nursery and holding habitat for salmonids.

There were a few areas that had dense strands of *Ranunculus* with good mussel beds around them.

For the majority of the surveyed sections the fall in the river was generally low with the exception of Section 15 downstream of Formil Bridge, which had a steeper gradient, fast flowing water and wall-to-wall large boulders with a tree lined southern bank. The bed material and fast flowing nature of this section is likely to blame for the absence of mussels.

The land along the banks of the Owenreagh downstream of the farm bridge was mostly unimproved grassland, heather and occasional trees/shrubs.

Fine sediment (redox)

Redox assessment was carried out, for the first time, at Fox's Bridge (H602 819) (Table 18). Redox potential difference between open water and interstitial water at 5cm depth was 24%, just above the 20% threshold for a functioning freshwater pearl mussel population (JNCC, 2015).

Section	Location	% loss at 5cm	
		2011	2016
5-12	Fox's Bridge (H602 819)	not assessed	24

Table 18: Redox potential measurements at sites in the Owenreagh River proposed ASSI

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >10% in slower velocity areas but in faster flowing stretches was <5%.

Fish host population assessment

During this survey, Atlantic salmon were found to be the preferred hosts for freshwater pearl mussel in the Owenreagh River. This survey is the first to report this finding and was confirmed through electrofishing and gill inspection for glochidia encystment.

Electrofishing was undertaken at upstream of Fox's Bridge (H602 819) in survey section 5-12. A 25-metre length of river was fished, upstream of the bridge, with an average channel

width of 6 metres; the area fished was therefore 150m^2. A total of 98 salmonids were captured comprising 22 trout and 76 salmon of various age classes.

Size-frequency analysis of the salmon population (Fig. 18) revealed that all 76 were 0+ and 1+ age classes resulting in a host density of 0.51 salmon/m^2.

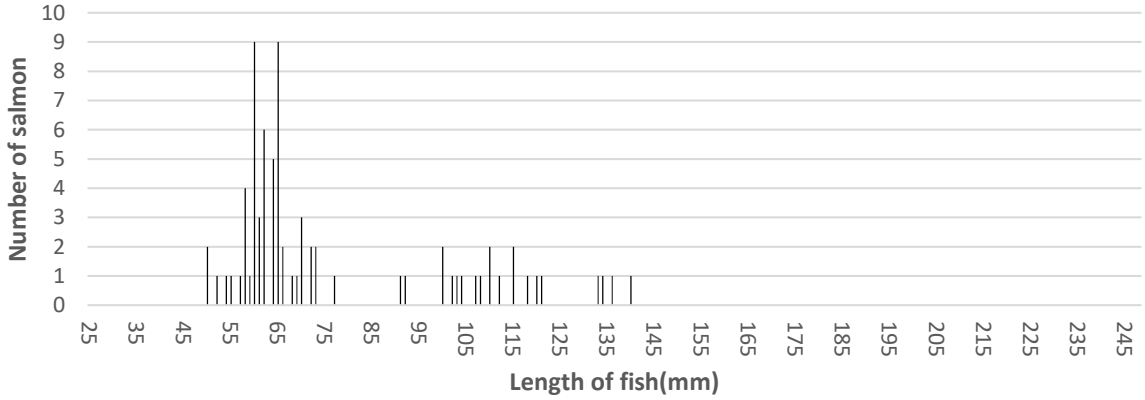


Figure 18: Size-frequency distribution of Atlantic salmon caught at Fox's Bridge (H602 819) on the Owenreagh River ASSI

Glochidia infection assessment

Of the 76 salmon captured during electrofishing, 38 were infected with glochidia (Fig. 19). This represents a 50% infection rate of available host salmonids in the electrofished stretch. Glochidia infection rates were high, typically around 100 glochidia per fish. Both 0+ and 1+ year class fish were infected.

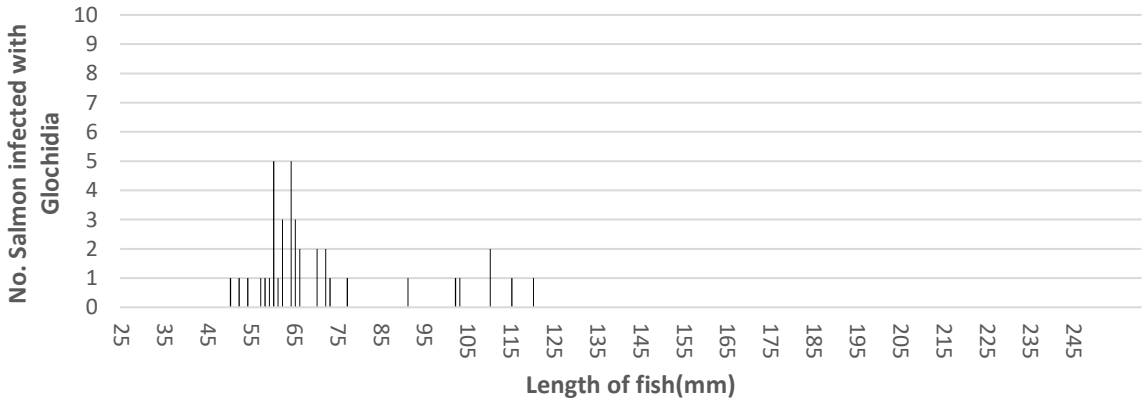


Figure 19: Size-frequency distribution of salmon and infected with glochidia caught at Fox's Bridge (H602 819) on the Owenreagh River ASSI

Alien/locally non-native species

No non-native invasive species were noted during the surveys.

Stocking transfers of other species

No stock transfers of other species are known to have taken place.

Introduction/transfer of freshwater pearl mussel

No introduction or transfer of freshwater pearl mussel have taken place.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the ASSI.

In-stream activities

There was no evidence of recent drainage or bed damage to the ASSI during this survey period. Some banks shows evidence of cattle trampling and erosion. There was a mixture of fenced and unfenced fields along the ASSI, so cattle can and do access the river at certain points but no trampling of mussels was observed at the time.

A ford crosses the river at H593 819 to allow machinery and livestock to cross.

Table 19: Conservation Assessment for the Owenreagh ASSI freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Dense beds of mussels of more than 100 individuals.	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	Transects not established in previous survey. 9750 live mussels observed (+18.97% increase in numbers on the previous assessment in 2011) **Estimated average – 0.59 mussels/m^2**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	None	FAIL
	ii. At least one mussel ≤30mm.	None	FAIL
d. Dead shells	<1% of population per year and scattered distribution.	24 dead, 9750 living (0.25%)	PASS
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.01 mg L^{-1} (range 0.01-0.07)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	0.035 mg L^{-1} (range 0.08-0.76)	PASS
BOD	Mean BOD <1.0 mg L^{-1}	1.53 mg L^{-1} (range 1.0-3.2)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a	No flow impediment structures.	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	minimum, UKTAG standards for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	24%	FAIL
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	5-10% cover across assessment units.	FAIL
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.51 salmon/m^2	PASS
	2. Should be able to find fish infected with glochidia between September and May.	38 (50%) of salmon were infected with glochidia	PASS
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	None	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	None	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	None	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS
*** i. In-stream activities**	No evidence of damage of existing mussel beds.	Cattle trampling of river banks and cattle accessing channel for drinking	FAIL
OVERALL CONDITION: UNFAVOURABLE – NO CHANGE			

8. Tempo River ASSI

The three sections on the Tempo River ASSI previously surveyed in 2011 (Reid *et al.*) were assessed (Fig. 20).

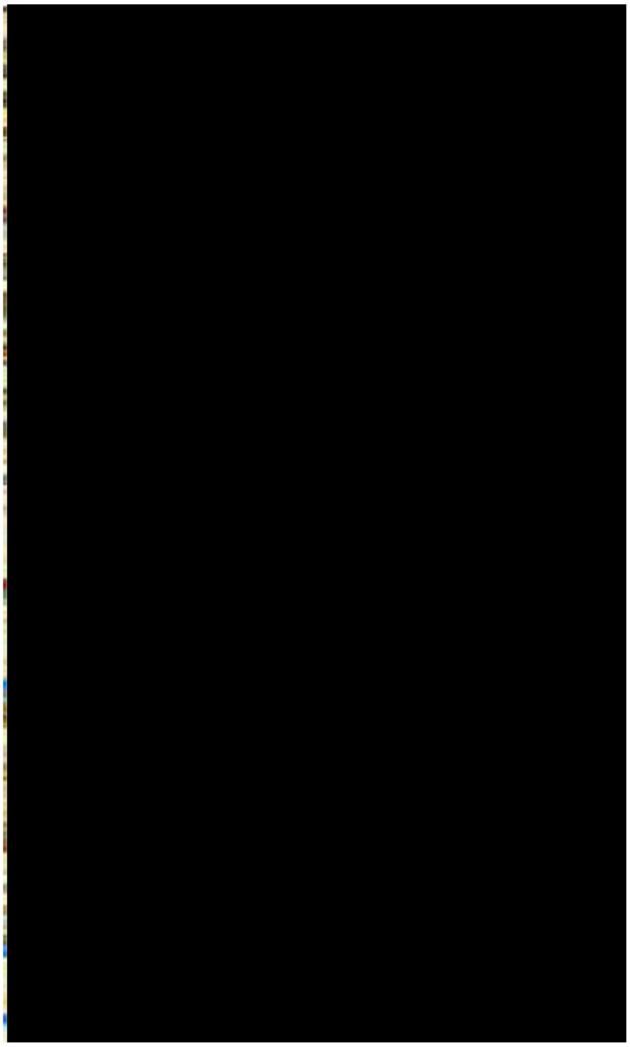


Figure 20: Map showing the survey sections on the Tempo River ASSI, numbered to be consistent with previous survey in 2011 (Reid *et al.*). (Map source Reid *et al.* 2011)

Population

In the survey sections, a total of 413 live mussels were observed (Table 20). This represents a 4.18% decrease on the 431 mussels reported in 2011 and a 21.33% decrease on the 525 mussels reported in 2009. The spatial extent of the mussels was characteristically extant beds of less than 100 individuals.

Section	No. of mussels			
	2006*	2009†	2011	2017
1/D*/E†	100	181	125	163
2/G*/I†	200	169	162	162
3/P*/R†	170	175	144	88

Total	**470**	**525**	**431**	**413**

Table 20: Number of live mussels observed in the Tempo River ASSI survey Sections in this survey and previous survey in 2006 (Preston), 2009 (Wilson) and 2011 (Reid *et al.*).

No length measurement of live mussels was undertaken due to the low density of the population.

A total of 12 shells were recovered from the three survey sections of the ASSI, ranging in length from 90.26 – 114.04mm. This is a -+0% change on the 12 shells collected during the 2011 (Reid *et al.*) survey.

Size-frequency analysis of the shells (Fig. 21) suggests that the population is comprised largely of adults, and therefore aging, mussels; noted in the previous survey (Reid *et al*, 2011). No shells <65mm length were recovered.

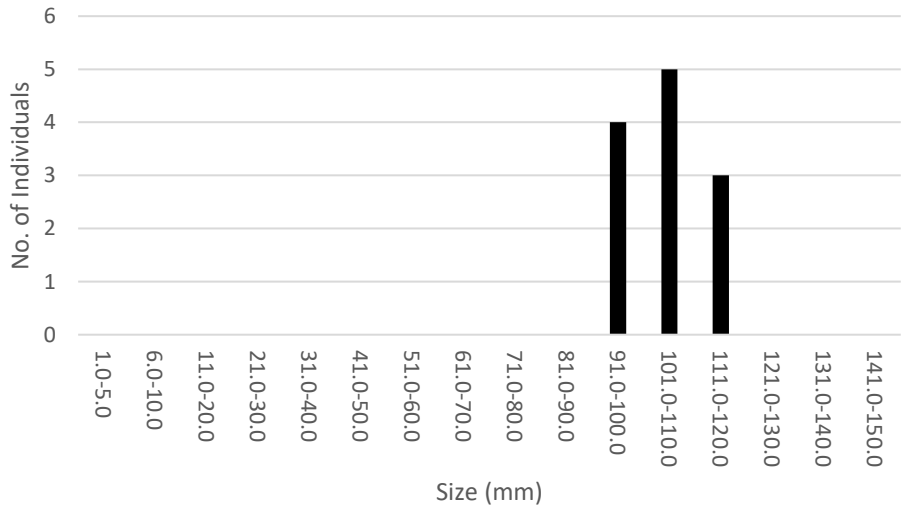


Figure 21: Size-frequency distribution of shell length (longest axis) of deceased mussels (empty shells) from the Tempo River ASSI

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at the A4 road bridge (H342 392) which is located downstream of the survey sites.

The data obtained from NIEA covered the period January 2011 to March 2017 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 21) shows that phosphorus, nitrogen-nitrate and BOD were all above the target thresholds for freshwater pearl mussel (JNCC, 2015). Suspended solids were generally lower than the threshold of 10mg/l, although on several occasions rose above this threshold. These exceedance events are common winter and early spring. There were however two very large exceedances of 182mg/l on 17.04.2012 and 134mg/l on 11.10.2012 which suggests that some significant event happened in the catchment that resulted is high runoff of sediment from the land.

Constituent	Range	Mean
Phosphorus	0.01-0.59	0.02
Nitrogen-Nitrate	0.39-1.53	0.90
Suspended Solids	2.00-182	8.90
BOD	1.00-3.20	2.16

Table 21: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Tempo River ASSI (data obtained from NIEA Water Management Unit)

Flow

There are no flow regulation structures upstream, of the survey sections.

Habitat Structure

The majority of mussels were found in Section 1 under the A5 road bridge. The substrate here was mostly a mixture of sand and gravel. Mussels found in higher number along the western side of the channel with a few found in finer material on the eastern side.

Upstream of the A5 Road Bridge there was a mixture of improved grassland and natural woodland. The river bed was generally finer material in comparison to the other surveyed rivers with a lot of silt. Good quality salmonid spawning/nursery/holding habitat wasn't abundant here and fish numbers at the surveyed site reflected this.

Fine sediment (redox)

Redox assessment was carried out, for the first time, at two sites on the Tempo River ASSI (Table 22). Redox potential difference between open water and interstitial water at 5cm depth was above the 20% threshold (range 45.3-47%) for a functioning freshwater pearl mussel population (JNCC, 2015).

Section	Location	% loss at 5cm	
		2011	2016
2	H339 397	not assessed	47
3	H335 427	not assessed	45.3

Table 22: Redox potential measurements at sites in the Tempo River ASSI

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >10%.

Fish host population assessment

During this survey, it was not possible to determine host preference for freshwater pearl mussel in the Tempo River as no infected fish were found. Electrofishing in both the

Swanlinbar and Waterfoot rivers has shown that glochidia can attach to both trout and salmon. As the Tempo River is in the Erne catchment, along with the Swanlinbar and Waterfoot rivers, an assumption is made here that glochidia could attach to both salmonid species in this river also.

Electrofishing was undertaken at Maguiresbridge ford (H 339 398) in survey section 3. A 36-metre length of river was fished, upstream of (H 339 398), with an average channel width of 10 metres; the area fished was therefore 360m^2. A total of 30 salmonids were captured comprising 27 trout and 3 salmon of various age classes.

Size-frequency analysis of the trout population (Fig. 22) revealed 19 were 0+ and 1+ age classes resulting in a host density of 0.05 trout/m^2.

Size-frequency analysis of the salmon population (Fig. 22) revealed that all 3 were 0+ and 1+ age classes resulting in a host density of 0.008 salmon/m^2.

As both trout and salmon are assumed to be suitable as hosts, the combined total of trout and salmon (22 salmonids) provided a host fish density of 0.06 salmonids/m^2.

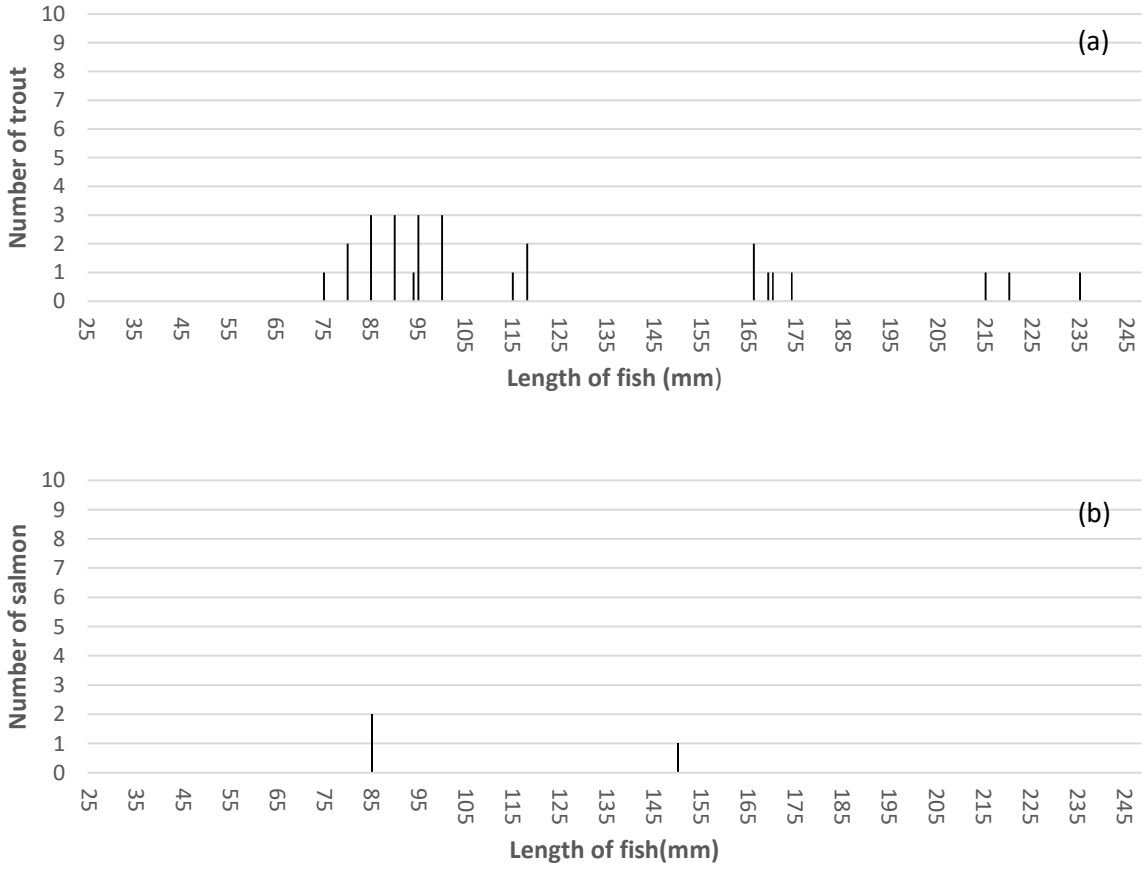


Figure 22: Size-frequency distribution of (a) trout and (b) Atlantic salmon caught at Maguiresbridge ford (H 339 398) on the Tempo River ASSI

Glochidia infection assessment

Of the 30 salmonids captured during electrofishing, none were infected with glochidia.

Alien/locally non-native species

No non-native invasive species were noted during the surveys.

Stocking transfers of other species

Trout were stocked here for a short period in the late 1990's/early 2000's from the Marlbank Hatchery at Florence Court through the Erne & Melvin Enhancement Company (EMEC), however no recent stocking of fish has been undertaken.

Introduction/transfer of freshwater pearl mussel

No introduction or transfer of freshwater pearl mussel have taken place.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the SAC.

In-stream activities

The majority of mussels where found in gravel along the road bridge wall.

The gravel in the river seems to be silted and the salmonid nursery habitat wasn't as good as other rivers surveyed.

Most fields were fenced; however, some were poorly fenced. Despite this, no cattle were seen accessing the river for drinking.

Table 23: Conservation Assessment for the Tempo ASSI freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Extant beds of mussels of less than 100 individuals.	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	Transects not established in previous survey. 413 live mussels observed (-4.18% decrease in numbers on the previous assessment in 2011) **Estimated average – 0.17 mussels/m^2**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	None	FAIL
	ii. At least one mussel ≤30mm.	None	FAIL
d. Dead shells	<1% of population per year and scattered distribution.	12 dead, 413 living (2.9%)	FAIL
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.02 mg L^{-1} (range 0.01-0.59)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	0.90 mg L^{-1} (range 0.39-1.53)	FAIL
BOD	Mean BOD <1.0 mg L^{-1}	2.16 mg L^{-1} (range 1.0-3.2)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards	No flow impediment structures.	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Range 45.3-47%	FAIL
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	>10% cover across assessment units.	FAIL
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.06 salmonids/m^2 (assumption that both salmon and trout are potential hosts)	FAIL
	2. Should be able to find fish infected with glochidia between September and May.	0 (0%) of salmonids were infected with glochidia	FAIL
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	None	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	No recent stocking of hatchery trout/salmon known to have taken place	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	None	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS
*** i. In-stream activities**	No evidence of damage of existing mussel beds.	Poorly fenced fields but no obvious signs of cattle trampling	PASS
OVERALL CONDITION: UNFAVOURABLE – DECLINING			

9. Waterfoot River proposed ASSI

The three sections on the Waterfoot River proposed ASSI previously surveyed in 2011 (Reid *et al.*) were assessed (Fig. 23).

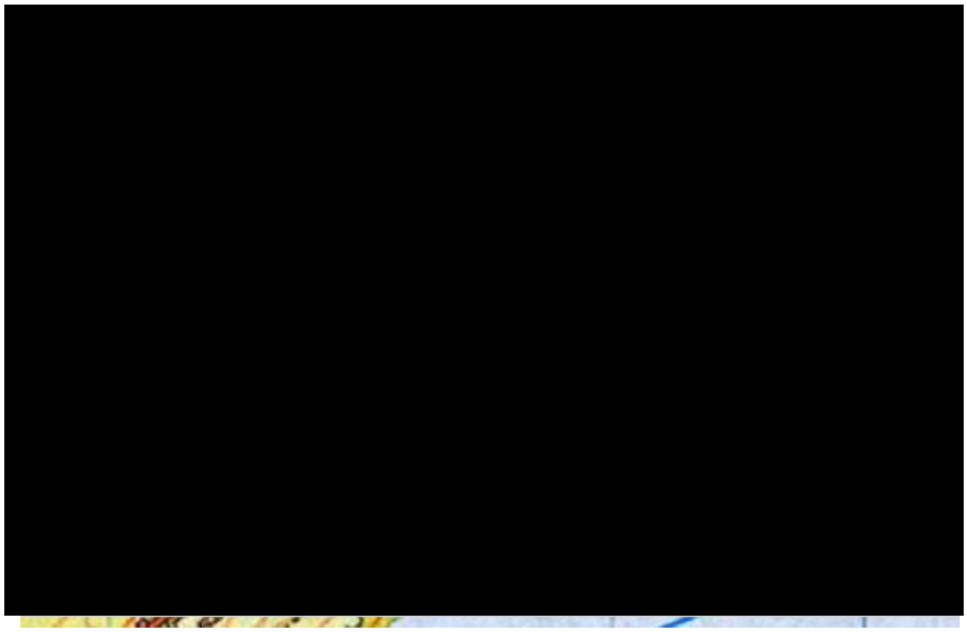


Figure 23: Map showing the survey sections on the Waterfoot River proposed ASSI, numbered to be consistent with previous surveys in 2007 (Killen) and 2011 (Reid *et al.*). (Map source Reid *et al.* 2011)

Population

In the survey sections, a total of 1023 live mussels were observed (Table 24). This represents a 152% increase on the 406 mussels reported in 2011 (Reid *et al.*). Comparison has not been made to the previous surveys in 2009 (Wilson) and 2006 (Preston) as the areas surveyed are not directly comparable.

The spatial extent of the mussels was characteristically dispersed with some large beds.

Section	Location	No. of mussels	
		2011	2016
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]

Table 24: Number of live mussels observed in the Waterfoot River proposed ASSI survey Sections in this survey and previous survey.

No length measurement of live mussels was undertaken due to the low density of the population.

No dead shells were recovered during this current survey, as was the case in the 2011 survey (Reid *et al.)*.

Water Quality

Water chemistry was derived from data collected by the Northern Ireland Environment Agency at Letter Bridge (H085 652) which is located downstream of the survey sites.

The data obtained from NIEA covered the period January 2011 to March 2017 and included phosphorus, nitrogen-nitrate, suspended solids and biological oxygen demand (BOD).

Analysis of the results (Table 25) shows that phosphorus, nitrogen-nitrate and BOD were above the target thresholds for freshwater pearl mussel (JNCC, 2015). Only suspended solids were generally lower than the threshold of 10mg/l, with only two occasions rising above this threshold.

Constituent	Range	Mean
Phosphorus	0.01-0.04	0.01
Nitrogen-Nitrate	0.05-0.69	0.35
Suspended Solids	2.00-18.0	4.90
BOD	1.00-3.70	1.60

Table 25: Range and Mean levels of chemical water quality indices for freshwater pearl mussel habitat condition in the Waterfoot River proposed ASSI (data obtained from NIEA Water Management Unit)

Flow

There are no flow regulation structures upstream, of the survey sections.

Habitat Structure

The bed material in the Waterfoot consisted of coarse gravels and cobbles with fewer amounts of sands. There was a good pool-riffle sequence for salmonids and the water was dark with a peat stained colour.

There was no drainage works evident at the surveyed sections.

Several fallen trees had collected gravel around them and they sported good numbers of mussels, perhaps acting as protection from flood waters.

The riparian banks along the survey sections was extensive natural woodland, mostly hazel, along with small fields of unimproved grassland.

Fine sediment (redox)

No redox assessment was undertaken in the Waterfoot due to a fault with the equipment.

Fine sediment (siltation)

Proportion of Sediment-sensitive Invertebrates (PSI) targets were not applied during this assessment.

Filamentous algae

Filamentous algae cover was generally >5%.

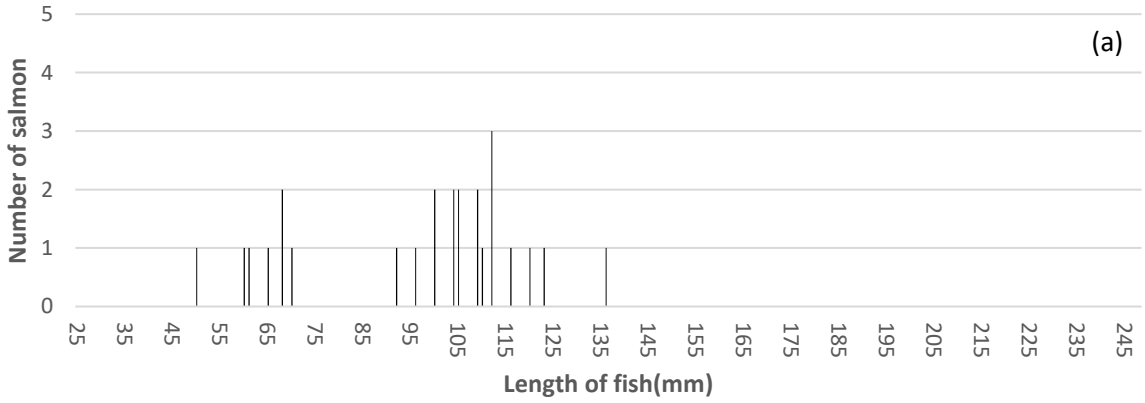
Fish host population assessment

During this survey, both Atlantic salmon and trout were found to be hosts for freshwater pearl mussel in the Waterfoot River ASSI. This survey is the first to report this finding and was confirmed through electrofishing and gill inspection for glochidia encystment.

Electrofishing was undertaken at Letter Bridge (H395 975). A 20-metre length of river was fished, upstream of Letter Bridge, with an average channel width of 8 metres; the area fished was therefore 160m^2. A total of 31 salmonids were captured comprising 6 trout and 25 salmon of various age classes.

Size-frequency analysis of the Atlantic salmon population (Fig. 24) revealed that all 25 of the salmon caught were 0+ and 1+ age classes resulting in a density of 0.16 salmon/m^2.

Size-frequency analysis of the trout population (Fig. 24) revealed that all 6 of the trout were 0+ and 1+ age classes resulting in a density of 0.04 trout/m^2.



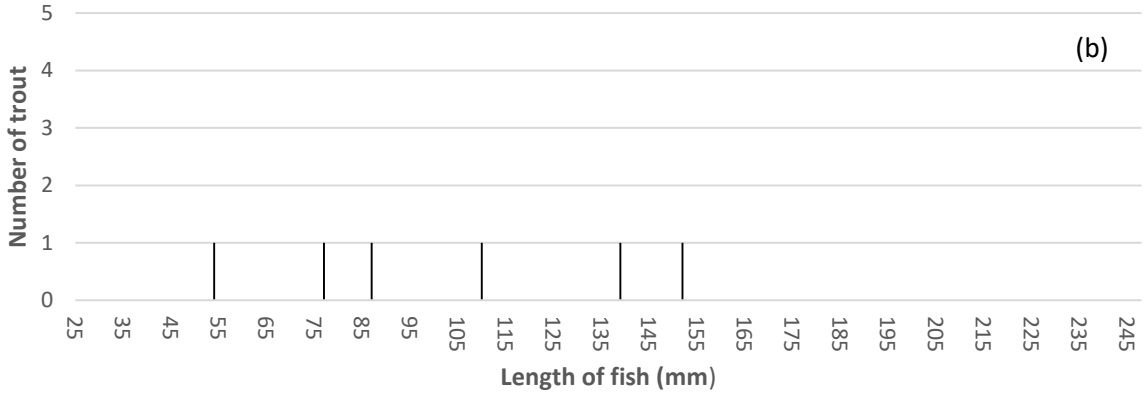
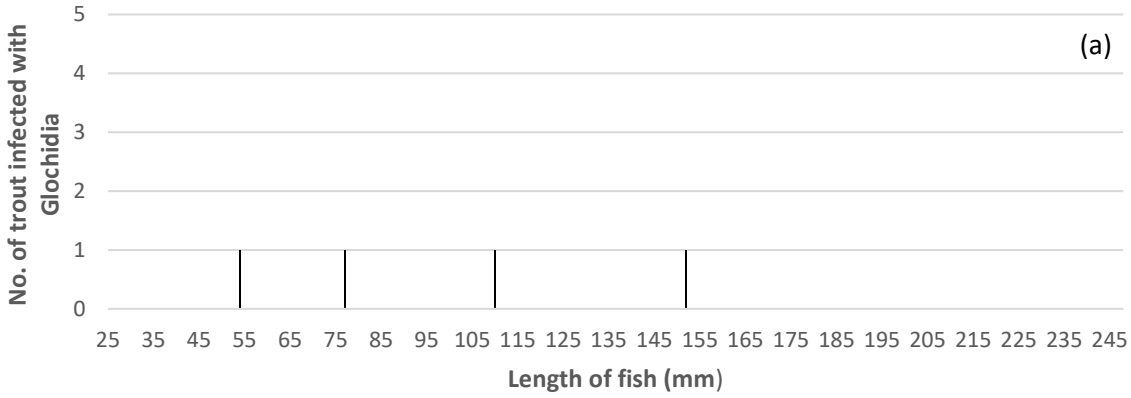


Figure 24: Size-frequency distribution of (a) Atlantic salmon and (b) trout caught at Letter Bridge (H395 975) on the Waterfoot River ASSI.

As both trout and salmon are suitable as hosts, the combined total of trout and salmon (31 salmonids) provided a host fish density of 0.2 salmonids/m^2.

Glochidia infection assessment

Of the 31 trout and salmon captured during electrofishing, 5 salmonids (4 trout and 1 salmon) were infected with glochidia (Fig. 25). This represents a 16% infection rate of available host salmonids in the electrofished stretch. Glochidia infection rates were relatively low, typically 10-20 glochidia per fish. Both 0+ and 1+ year class trout were infected whilst only one 1+ salmon was found carrying glochidia.



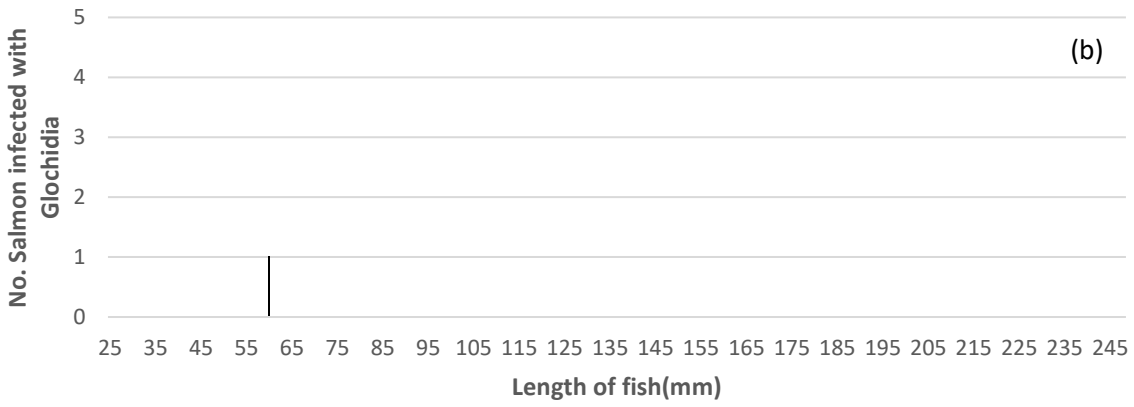


Figure 25: Size-frequency distribution of (a) trout and (b) Atlantic salmon infected with glochidia caught at Letter Bridge (H395 975) on the Waterfoot River ASSI.

Alien/locally non-native species

No non-native invasive species were noted during the surveys.

Stocking transfers of other species

Trout were stocked here for a short period in the late 1990's/early 2000's from the Marlbank Hatchery at Florence Court through the Erne & Melvin Enhancement Company (EMEC), however no recent stocking of fish has been undertaken.

Introduction/transfer of freshwater pearl mussel

No introduction or transfer of freshwater pearl mussel have taken place.

Pearl fishing

No evidence of pearl fishing was observed during the survey.

No pearl fishing has been reported in the SAC.

In-stream activities

Cattle were excluded from the survey sites on the Waterfoot River. The majority of the site was tree-lined and thus banks were stable. Several fallen tree were found across the channel but they had allowed gravel to build up and many mussels were found here.

There was no sign of damage to the sites during this survey.

Table 26: Conservation Assessment for the Waterfoot proposed ASSI freshwater pearl mussel population

Attribute (* = discretionary)	Target	Actual	Pass/Fail
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Extant beds of mussels of some beds of more than 100 individuals but with areas of unoccupied habitat.	FAIL
b. Population density	≥ 5 mussels per m^2 within sample transects.	Transects not established in previous survey. 1023 live mussels observed (+152% increase in numbers on the previous assessment in 2011) **Estimated average – 0.75 mussels/m^2**	FAIL
c. Age structure	i. At least 20% of population ≤65mm	None	FAIL
	ii. At least one mussel ≤30mm.	None	FAIL
d. Dead shells	<1% of population per year and scattered distribution.	0 dead, 1023 living (0%)	PASS
WATER QUALITY			
Phosphorus	Mean P of <0.005 mg L^{-1}	0.01 mg L^{-1} (range 0.01-0.04)	FAIL
Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	0.35 mg L^{-1} (range 0.05-0.69)	FAIL
BOD	Mean BOD <1.0 mg L^{-1}	1.60 mg L^{-1} (range 1.0-3.7)	FAIL
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole	No flow impediment structures.	PASS

Attribute (* = discretionary)	Target	Actual	Pass/Fail
	biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.		
HABITAT STRUCTURE			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth*	Not Assessed	Unknown
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Not Assessed	Unknown
c. Filamentous algae	<5% cover across assessment units.	>10% cover across assessment units.	FAIL
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2.	0.2 salmonids/m^2 (assumption that both salmon and trout are potential hosts)	PASS
	2. Should be able to find fish infected with glochidia between September and May.	5 (16%) of salmonids were infected with glochidia	PASS
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	None	PASS
*** f. Stocking transfers of other species**	No inappropriate stocking/translocation of fish species.	No recent stocking of hatchery trout/salmon known to have taken place	PASS
*** g. Introduction/ transfers of freshwater pearl mussel**	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	None	PASS
*** h. Pearl fishing**	No evidence of pearl fishing.	None	PASS
*** i. In-stream activities**	No evidence of damage of existing mussel beds.	Livestock excluded. Stable banks	PASS
OVERALL CONDITION: UNFAVOURABLE – NO CHANGE			

10. Discussion

Overall a total of 24,396 freshwater pearl mussels were recorded in the defined survey sections on six rivers throughout Northern Ireland, compared with 21,979 recorded in the previous survey (Reid *et al.*, 2011). This is an increase of 2,417 (+11% increase) on the previous survey total.

This increase is not attributably to mussel recruitment as few mussels <65mm were found but is most likely related to survey effort being greater in this assessment than in previous surveys.

SAC Rivers

A total of 13,210 freshwater pearl mussel was recorded in the survey stretches on the SAC rivers (Owenkillew, Swanlinbar, Upper Ballinderry). This is an increase of 263 individuals (+2.03% increase) on the 12,947 recorded during the previous survey (Reid *et al*., 2011). This increase was despite survey Point transects B1-B8 on the Owenkillew River not being surveyed during this assessment.

The Owenkillew River Condition status remained as Unfavourable – No Change as, whilst more mussels were counted than in the previous survey, and death rate as a percentage of the living population had reduced, only two mussels <65 mm were found in the four transects assessed and no mussels <30mm were observed, suggesting recruitment is low and below sustainable levels.

The Swanlinbar River Condition status was reclassified from No Change in the 2011 survey to Unfavourable – Declining as despite more mussels being counted than in the previous survey, death rate as a percentage of the living population had increased and no mussels <65mm were observed, suggesting recruitment is low and below sustainable levels.

The Upper Ballinderry River Condition status was reclassified from No Change in the 2011 survey to Unfavourable – Declining due to less mussels being counted than in the previous survey, death rate as a percentage of the living population increasing and no mussels <65mm were observed, suggesting recruitment is low and below sustainable levels.

Water quality in all the SAC's remained above maximum thresholds for good freshwater pearl mussel habitat, with Phosphate increasing at some sites since 2011.

In the Owenkillew, stock exclusion fencing would greatly benefit the site to avoid the direct trampling of mussels by cattle and the indirect impact of cattle trampling riverbanks and delivering excessive amounts of silt to mussel beds.

ASSI and proposed ASSI Rivers

A total of 11,186 freshwater pearl mussel was recorded in the survey stretches on the ASSI and proposed rivers (Owenreagh, Tempo, Waterfoot). This is an increase of 2,154 (+23.85% increase) on the 9,032 recorded during the previous survey (Reid *et al*., 2011).

The Owenreagh River proposed ASSI Condition status remained as Unfavourable – No Change as, whilst more mussels were counted than in the previous survey, and death rate as a percentage of the living population had reduced, no mussels <65 mm were found.

The Tempo River ASSI Condition status remained as Unfavourable – Declining as slightly fewer mussels were counted than in the previous survey, no mussels <65mm were observed and the Tempo was the only river that failed the abundance parameter for native juvenile host salmonids. It was also the only river where no glochidia were seen on the gills of fish, suggesting that host fish density and infection probability is low. Should this continue, the population faces a long-term decline with the aging population eventually dying out.

The Waterfoot River proposed ASSI Condition status remained as Unfavourable - No Change as, despite +152% more mussels being counted and the death rate as a percentage of the living population remained at zero (as in the 2011 survey) and no mussels <65mm were observed. Water quality parameter also failed to meet the thresholds for freshwater pearl mussel habitat. It can therefore not be concluded that the site is Recovering.

Water quality in all the rivers remained above maximum thresholds for good freshwater pearl mussel habitat, with Phosphate increasing at some sites since 2011.

Additional surveys

It should be noted that additional mussel surveys were carried out on the Ballinderry River along the entire 47-kilometre length of the bed of the river and the Owenkillew River along the entire length of Survey Section 12. These additional surveys bring the total recorded, known, freshwater pearl mussel population in Northern Irelands SAC rivers up to 16,700 individuals.

On the Ballinderry River total of 1,468 mussels were recorded with the majority being in the upper reaches of the river. This represents the most comprehensive survey of a freshwater pearl mussel river in Northern Ireland. Only 35% of the river's mussel population are to be found in the defined SAC Condition Assessment monitoring sections (Section 16, 17, 20-22).

On the Owenkillew River, a total of 3854 mussels were recorded in Section 12 with only 34% of the mussels occurring within the defined monitoring units (A-M) inside of Survey Section 12.

As only about a third of the population in each river reach is assessed when visiting the designated survey sections, it is hard to determine whether a decrease in mussels is related to mortality or the downstream movement of mussels between surveys.

Mortality or Downstream population drift?

It is our conclusion that downstream movement of mussel plays and important part in the changing number of mussels in survey sections between surveys, as this can be seen on the Owenreagh ASSI where the survey in 2011 and this survey has provided a population distribution profile over a ~2.8km continuous stretch of river and shows a downstream drift in the population over the intervening 6 years (Fig. 26).

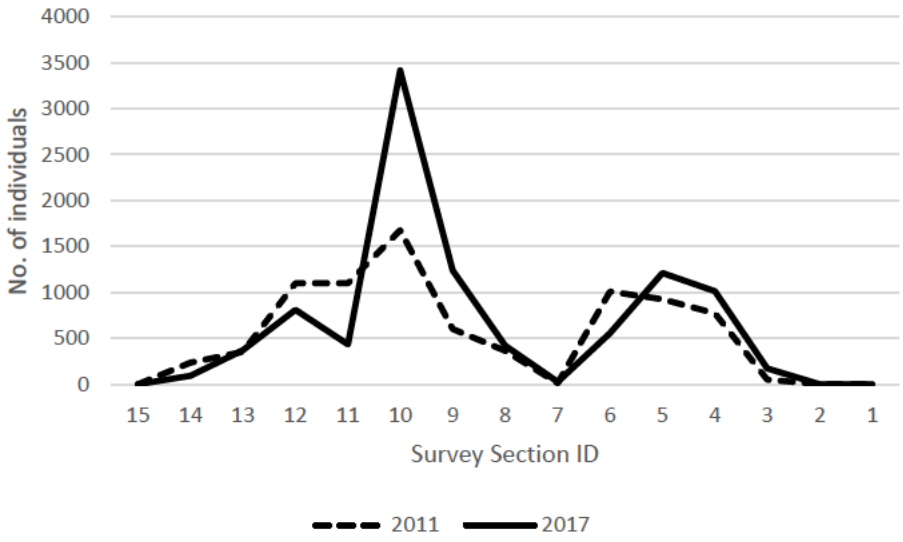


Figure 26: Number of mussels observed at each survey section (15-1) during the 2011 (dotted line) and 2017 (solid line) surveys with Section 15 being upstream and Section 1 being downstream.

The 'disappearance' of mussels from Sections 15-11 appears to be explained by the increase in mussels in Sections 10-9. It is also apparent to see the downstream drift of mussels over time between Sections 6-2.

As it appears that no mussels are being 'washed in' at the top of the stretch it is inevitable to conclude that, in time, the number of mussels will decrease largely due to them migrating out of the survey stretch and not due to mortality alone.

That said, as there is little recruitment, the population will ultimately age and die, if conditions are not improved to allow the downstream migrating population to recruit and repopulate unoccupied upstream habitat.

Restoration of freshwater pearl mussel on the Ballinderry River SAC

Following the Condition Assessment survey on the Ballinderry River in 2016, Ballinderry Rivers Trust released 1500 captive-bred juvenile mussels, ranging in size from 3-8cm, into Survey Section 17 in July 2017. This release is part on an ongoing freshwater pearl mussel restoration project funded by the Northern Ireland Environment Agency, through its Environment Fund.

Furthermore, 498 captive-bred juvenile mussels were released at a site near Dunamore near the top of the Upper Ballinderry River SAC and 250 more released to the Gortin Water tributary of the SAC.

Given that the comprehensive survey of the Ballinderry River, undertaken during this survey, counted 1468 mussels in the entire 47km length of the river channel, this release of 2284 mussels represents a 153% increase on the number of mussels in the river.

Based on the Condition Assessment made in 2016 condition is determined as Unfavourable – Declining, however, it is hoped that with continued releases of mussels and ongoing silt remediation works and water quality improvement projects being undertaken by the Trust, in partnership with local landowners, the condition of the Ballinderry population, when assessed again for the next reporting round will be more favourable – towards recovery.

11. Conclusion

All of Northern Ireland freshwater pearl mussel populations remain imperilled.

Conservation efforts on the Ballinderry River, to address siltation problems at a catchment-scale and redress the population structure imbalance through the reintroduction of captive bred juvenile mussels, are beginning to show measured success. However, both habitat improvement to the level required for juvenile mussel survival, at such a scale, takes time and results, albeit positive, are inevitably slow in being achieved.

Catchment-scale water quality and habitat improvement works are required on all of Northern Ireland's freshwater pearl mussel rivers to address on-going chemical water quality issues, siltation of river substrate and direct impacts to mussel's survival, such as cattle trampling. These are required to create the conditions necessary for natural recruitment, before the wild populations reach a point where they are no longer able to naturally reproduce, or indeed become extinct. We still have a chance to save these populations but, given the time it takes to achieve meaningful results, the window of opportunity is rapidly closing.

12. Acknowledgements

Thanks to Grace McGurk, Jake Johnston, Ross Polke and Claire Mitchell for volunteering their time to surveys and measuring of shells.

Thanks also to Mert Thompson of the Northern Ireland Environment Agency for supporting this survey through his role as Project Liaison for the Environment Fund.

Finally, thanks to the Northern Ireland Environment Agency's Environment Fund for funding this survey.

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