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An assessment of electrofishing and habitat survey data for a fish barrier removal:

Creamery Weir - Twynholm

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Summary

An assessment of electrofishing and habitat survey data for a fish barrier removal:

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Keywords

Salmon: Brown trout; Eel; Electrofishing; Creamery Weir; Kirk Burn; Old Mill Burn; Tarff Water; River Dee (Kirkcudbright); Baseline data collection; Post-work fish monitoring

Background

In 2012, Galloway Fisheries Trust (GFT) identified a redundant weir 3.5 m high and 13 m wide, associated with a disused creamery situated on the Old Mill Burn (a tributary of the Tarff Water) near Twynholm, Dumfries and Galloway, as impacting significantly on local fish stocks. This weir (constructed >100 years ago) presented a complete barrier to migratory salmonid fish species considered important for economic and conservation reasons and blocked access to 10 km of good quality upstream river habitat and transfer of gravels downstream. Allowing migratory fish access to this habitat was considered by GFT as a priority for action.

Through the Rivers and Fisheries Trusts of Scotland (RAFTS) Barrier Easement Project, an opportunity arose to consider the weir, positioned at NGR NX 67410 55106, for easement options using the Scottish Environment Protection Agency (SEPA) managed Water Environment Fund (WEF). Between 2014 and 2016 SEPA WEF provided background environmental information and majority funding for the practical engineering works in 2016 and also the pre-works including: 2014 feasibility study conducted by ARUP, 2015 impact assessment completed by JBA Consulting and 2016 design and build phase of works, in which Royal Haskoning DHV were the design supervisors during works and Ebsford Environmental Limited were the works contractors.

RAFTS managed the project programme and contracted engineering works. GFT facilitated and mentored the project and provided essential local knowledge, ran a stakeholder information event, organised the pre-work fish rescues and will continue to monitor the fish populations as they repopulate to the burn in future. To provide fisheries data to support each project phase, GFT have undertaken electrofishing surveys within the Old Mill Burn and in 2017, the first monitoring electrofishing was completed to catalogue recovery of migratory fish to the Old Mill Burn upstream of the Creamery Weir site.

Main findings

- No juvenile salmon were found within six sites surveyed above the weir during pre-work surveys, completed in 2012, 2013, 2015 and 2016 within the Old Mill Burn. In 2017, during the first year of post-work monitoring, salmon were found in one of the two sites electrofished upstream of the demolished weir site, as fry in a high density (indicating that successful spawning of wild salmon had taken place during the winter of 2016).

- Juvenile Brown trout were found at four of the six sites surveyed above the weir during pre-work surveys completed in 2012 (generally in low to moderate density) and 2016 (in low to high density).

- Eels were found in five of the six sites surveyed upstream of the weir pre-works (2012 and 2016) from as far up the catchment as the Auchengassel Burn (tributary of the Kirk Burn) to the site at Twynholm. Eels were the only migratory fish found to be able to ascend the Creamery Weir – by means of mosses covering both sides of the structure. Post-works, eels were found in all sites electrofished upstream and downstream of the Creamery Weir site.

- During years 2-4 of monitoring (2018, 2019 and 2020), salmon were present in the downstream site and one of the upstream sites. Salmon fry densities dropped from 2017 to 2018 and were even lower in 2019. 2020 saw an increase in salmon fry densities at both sites. Salmon parr were present at both sites in 2018 however in 2019 salmon parr were only present within the middle site. In 2020 salmon parr were only present in the downstream site. Salmon have not yet returned to the highest upstream site. 2018 saw Brown trout fry were present at all sites during post monitoring works. Trout parr were not present within the downstream site in 2020.

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1. INTRODUCTION

During the development of the Solway-Tweed River Basin Management Plan, with guidance from Galloway Fisheries Trust (GFT), Scottish Environment Protection Agency (SEPA) identified the Creamery Weir as being a significant impact on fish accessing available fish habitat and highlighted it as a priority for action and suitable for support from the Water Environment Fund. By removing this barrier, the waterbody would be improved from Moderate Ecological Potential to Good Ecological Potential as classified by the Water Framework Directive.

A range of options were considered to solve the fish passage problem but it was decided that full removal would be the most sustainable and cost effective solution, removing maintenance and upkeep issues and future risk of weir failure. In 2015, data to create a design was gathered on utilities, topography and weir structure. The effects of removal on ecology, geomorphology, flood risk and fish passage were considered. The design was taken to the land owner, local Authority, a local Councillor and Scottish Natural Heritage (SNH) for review and comment. All were supportive. A public stakeholder information event was held in January 2016.

The design involved adaptive management of groundworks: monitoring the actual removal works and being prepared to modify the approach if necessary during the works.

The full removal works were completed over a four week period in September 2016 and involved:

- carefully excavating sediment from upstream of the weir to uncover the original river bed
- building rock steps similar to those that naturally occur just upstream to ensure river stability
- taking the weir down in carefully controlled stages
- removal of a sluice a short distance downstream to further aid fish migration
- silt control measures within a gorge which created various difficulties that had to be overcome

The project was a great success and achieved widespread attention from the local community, local press, BBC Radio Scotland and ITV Border News.

The Creamery Weir was situated upon the Old Mill Burn – a tributary of the Tarff Water, near Kirkcudbright. There is a variety of legislation, regulations and guidance in place relating to fish species that are present in watercourses within the Tarff catchment. Atlantic salmon are an internationally important fish population which is listed under Annex II and V of the European Habitats Directive (1992) (only in freshwater), Appendix III of the Bern Convention (1979) (only in freshwater) and are a local priority species in the Dumfries and Galloway Local Biodiversity Action Plan. Atlantic salmon are also a species of conservation concern on a UK level. The Kirkcudbrightshire Dee and Tarff Water are recognised as category 3 status rivers under The Conservation of Salmon (Scotland) Regulations 2016 with effect that mandatory catch and release of salmon must be undertaken. Brown trout/sea trout are also a UK Biodiversity Action Plan species. Brown trout are present throughout the Old Mill Burn.

There have been concerns around Europe over low eel stocks. It is currently unknown why there was such a rapid decline but it is possibly linked to over-exploitation, inland habitat loss, climate and ocean current changes, disease and pollution. European Eel Regulations (EC) No 1100/2007 aim to establish measures to recover eel stocks. One such measure was the production of Eel Management Plans for the Scotland River Basin and the Solway

Tweed River Basin District. Fishing or taking eels is illegal (unless licensed) under The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008. Eels are also a UKBAP priority species.

To monitor the long-term ecological gain that has resulted from the removal of the Creamery Weir, GFT will monitor juvenile fish populations by means of electrofishing. This report details the findings from electrofishing surveys undertaken by GFT in summer 2018, 2019 and 2020 and compares these to electrofishing data gathered pre-works between the years of 2012 and 2017 upon the Old Mill Burn and watercourses draining in to it. A range of sites will be surveyed annually for up to five years post-works to evaluate the natural recolonisation of the burn upstream of the demolished weir.

2. METHODOLOGY

2.1 Data recording

The GFT is a partner in the Scottish Fisheries Co-ordination Centre (SFCC), an initiative involving, amongst others, the Scottish Fishery Trusts; Marine Scotland Science; The Tweed Foundation; the Spey Research Trust; the Tay Foundation and the Cromarty Firth Fisheries Trust.

This group has, in partnership, developed a set of agreed methodologies and record sheets for use with electrofishing surveys, and an associated database in which to record information gathered from such surveys.

The electrofishing surveys undertaken by the GFT have been completed to the standards that are required by the SFCC and recorded using the agreed formats.

2.2 Electrofishing techniques

To assess the fish population present within a section of river various techniques have been developed in the recent decades. The main method of determining the health of a fish population is by the use of electrofishing equipment.

This technique involves the stunning of fish using an electric current which enables the operator to remove the fish from the water. Once captured, the fish recover in a holding container. They are then anaesthetised using a specific fish anaesthetic, identified to species, measured and recorded, and once recovered, returned unharmed to the area from which they were captured.

The method of fishing involves the anode operator drawing stunned fish downstream to a banner net held against the current by an assistant. A hand net operator completes the three-man team. Fish captured are then transferred to a water-filled recovery container. The team works its way across the section and upstream, thereby fishing thoroughly all the water in the surveyed area.

To obtain fully quantitative information on the fish populations within the river, each survey site is fished through up to four times consecutively to allow the calculation of a more accurate Zippin estimate of the fish population. A Zippin estimation of a fish population is a calculation carried out using a depletion method (multiple run fishing). This is an estimate of the fish population density per 100 m^2 of water, including the 95% confidence limits. When the calculation of a Zippin estimate of the population is not possible, a minimum estimate of the fish population is given for that section of river (this information is presented in Appendix 2).

When timed delineated surveys are undertaken, sites are electrofished for a given length of time and the number of fish caught regarded as an index of abundance (catch per unit of effort (time)) rather than determining fish density per unit area. This information is presented in Appendix 1.

It is policy to disinfect all relevant equipment both prior to and following work in each river catchment, to ensure that there is no transfer of disease organisms.

2.3 Electrofishing equipment used

A mobile, battery powered backpack electrofishing kit was used to undertake the survey. GFT employs the use of a 500 WATT E-Fish backpack electrofishing kit set to give a 300 volt output at 0.3 amps. All settings were set to maximise capture of juvenile salmonids. The backpack controller unit is linked to a stationary cathode of braided copper (placed instream) and a mobile, single anode, consisting of a pole-mounted stainless steel ring and trigger switch is used instream to capture the fish.

Smooth direct current was used in all survey sites.

2.4 Age determination

Electrofishing surveys concentrate on juvenile salmonid species, namely salmon (Salmo salar L.) and trout (Salmo trutta L.). In the majority of cases age determination of the fish present can be made by assessment of their length and scale-sample readings. However, with older fish it is more difficult to clarify age classes by fish length alone and therefore in this survey salmonid fry (0+ fish) were classified alongside salmonid parr (1+ fish and older). Information on juvenile densities can be found in Appendix 1-3.

2.5 Non-salmonid fish species

At each site the presence of non-salmonid fish species was also noted. Population densities for these species were not calculated. This information is presented in Appendix 1-3.

2.6 Site measurement

At each site surveyed where fully or semi quantitative techniques were employed, a total site length was recorded and average wet and dry widths calculated.

The average wet width was calculated from five individual widths recorded at equidistant intervals from the bottom of the site (0 m) to the top. At each site a final width was noted at the absolute upper limit of the surveyed water. From these site measurements the total area fished was calculated. Where timed electrofishing was undertaken (2017), site measurements were estimated (density of fish present is calculated as catch per unit effort (fish/min) rather than density of fish per 100 m^2 of water).

2.7 Bankside / instream habitat assessment

At each site an assessment was made of the instream habitat available for older (parr aged) fish. This assessment graded instream cover present as none, poor, moderate, good or excellent. This grading provides an index of instream cover where diverse substrate compositions will score more favourably than areas of uniform substrate providing poorer cover.

In accordance with SFCC protocols, percentage estimates of depths, substrate type and flow type were made at each site.

Additionally, percentage estimates of the quantity of the bankside features undercut banks, draped vegetation, bare banks and marginal vegetation were made.

All of these bankside and instream habitat site features are summarised in Section 4. When reference to left or right bank is made, it is always left and right bank when facing downstream.

Specific electrofishing site and habitat information are presented in Section 4 and Appendix 1-3.

2.8 Site selection

A range of sites were surveyed across the years to cover fish populations residing within the Old Mill Burn upstream and downstream of the Creamery Weir site. Initially (pre-works), sites were electrofished using semi-quantitative one-run techniques and latterly, timed electrofishing techniques were applied.

In total, three sites were surveyed for fish populations in 2018, 2019 and 2020. Surveys were carried out over two days in July and August 2018, 2019 and 2020.

3. RESULTS

3.1 Electrofishing results

3.1.1 Figures presented

The results of the post-works (monitoring) electrofishing survey are outlined in Section *3.1.3* and presented in detail in Appendix 1-3 *(Results from years two to four monitoring electrofishing surveys completed on the Old Mill Burn, post-works, 2018, 2019 and 2020*). These provide information on the population densities of juvenile salmonids at each site (fish per 100 m^2 or fish/minute). Site code, watercourse, site location, O.S. Grid reference, survey date, non-salmonid species and area fished (m^2) are also shown.

With regard to the juvenile salmonid age classes, these are separated into four categories, which are defined in Table 1:

Table 1: Salmonid age classes

Salmon Fry (0+):	Refers to young fish less than one year old resulting from spawning at the end of the previous year.
Trout Fry (0+):	Refers to young fish less than one year old resulting from spawning at the end of the previous year.
Salmon Parr (1+ and older):	Refers to young fish of greater than one year and greater than two years old (where present) from spawning years 2017 to 2018.
Trout Parr (1+ and older):	Refers to young fish of greater than one year and greater than two years old (where present) from spawning years 2017 to 2018. If captured, trout of up to three or four years old are also included in this category.

Within the electrofishing results, juvenile salmonid numbers recorded have been classified into several categories. A classification scheme for densities of salmonids was previously generated by the SFCC using data collected from 1,638 Scottish electrofishing survey sites, covering the period 1997 to 2002 (Godfrey, 2005[1]). From this, regional figures were created to allow more accurate local ranges. The categories are based on quintile ranges for one-sample electrofishing surveys in the Solway region (Solway Salmon Fishery Statistical Region), allowing densities of fish observed to be put into a regional context. Table 2 shows these quintile ranges.

Table 2: Quintile ranges for juvenile salmonids (per 100 m^2) based on one-sample electrofishing events, calculated on densities >0 over 291 sites in the Solway Statistical Region

	Salmon 0+	Salmon 1++	Trout 0+	Trout 1++
Minimum (Very Low)	0.22	0.38	0.38	0.35
20th Percentile (Low)	5.21	2.86	4.14	2.27
40th Percentile (Moderate)	12.68	5.87	12.09	4.71
60th Percentile (High)	25.28	9.12	26.63	8.25
80th Percentile (Very High)	46.53	15.03	56.49	16.28

[1] Godfrey, J. D., 2005; Site Condition Monitoring of Atlantic Salmon SACs: Report by the SFCC to Scottish Natural Heritage, Contract F02AC608.

3.1.2 Survey limitations

The juvenile salmonid density classification scheme is based solely on data from surveyed sites containing fish in the period 1997 to 2002, and refers to regional conditions at that time; therefore it must only be used as a very relative guide and not be used to draw conclusions. Moreover, the figures for juvenile trout are less reliable for various reasons (e.g. some surveyed populations of trout are isolated; sea trout contributing to stock in some areas etc) and so can only be used as a relative indication of numbers.

Electrofishing and habitat information is discussed, with reference to any specific issues such as sensitivities, in Section 4.

3.1.3 Electrofishing results

<u>2018 Electrofishing results</u>

- Site 1 (DTK1): Old Mill Burn Grid reference: 266540 554307

Salmon fry and parr were absent at site 1. Trout fry and parr were present in low and very low densities respectively. One eel was also found at this site as well as two stoneloach.

- Site 3 (DTK3): Old Mill Burn Grid reference: 267370 554970

Salmon fry and parr were found in a very low density at this site. Trout fry were present in a moderate density and trout parr were present in very low density. Three stoneloach were present at the site.

- Site 4 (DTK4): Old Mill Burn Grid reference: 268006 555482

Salmon fry and parr were found in a very low density at this site. Trout fry and parr were present in a very low density. Of the non-salmonid fish species, one eel and six stoneloach were found.

<u>2019 Electrofishing results</u>

- Site 1 (DTK1): Old Mill Burn Grid reference: 266540 554307

Salmon fry and parr were absent at site 1. Trout fry and parr were present in low densities. No other fish species were present.

- Site 3 (DTK3): Old Mill Burn Grid reference: 267370 554970

Salmon fry and parr were found in a very low density at this site. Trout fry and parr were found in a very low density at this site. No other fish species were present.

- Site 4 (DTK4): Old Mill Burn Grid reference: 268006 555482

Salmon fry were present in very low density. Salmon parr were not present within this site. Trout fry and parr were found in a very low density at this site. Of the non-salmonid fish species, two eels, a minnow and 51 stoneloach were present.

2020 Electrofishing results

- Site 1 (DTK1): Old Mill Burn Grid reference: 266540 554307

Salmon fry and parr were absent at site 1. Trout fry and parr were present in high and low density respectively. Two eels were also found at this site as well as stoneloach.

- Site 3 (DTK3): Old Mill Burn Grid reference: 267370 554970

Salmon fry were found in a low density at this site. Salmon parr were not present. Trout fry were present in a high density. Only a single trout parr was present. From the non-salmonid fish species, a single mature eel and stoneloach were present at this site.

- Site 4 (DTK4): Old Mill Burn Grid reference: 268006 555482

Salmon fry were present in low density. Salmon parr were not present within this site. Trout fry were present in a low density. Trout parr were absent from this site. Of the non-salmonid fish species, two eels, stoneloach and a minnow were found at this site.

4. DISCUSSION

4.1 Physical works undertaken

The Creamery Weir and associated sluice gate were removed in September 2016 and the sediment which had built up behind the weir removed to re-profile the river bank and protect the nearby road. Since the removal of the weir, the river has naturally re-profiled itself with erosion and deposition occurring within the work area. The Old Mill Burn runs through a gorge so there is limited room for the river to naturally move but the channel has shown some meandering above the Creamery Weir site. Seeding of parts of the banksides took place to assist in protecting the road and to ensure excessive levels of silt was not washed into the river. This seeding did not take place right down to the water edge to allow the river to undertake some erosion and realignment if required. The channel width and gradient of the new channel were designed to mimic the burn outside the work area.

River sediments are now able to move naturally through the site following the weir and sluice gates removal. This process will create more natural and suitable instream conditions for salmonids downstream, by the creation of pool and riffle sequences and formation of gravel beds.

Below are pictures taken pre and post demolition works at the sluice gate (Figure 1) and weir sites (Figure 2).

Figure 1: Creamery sluice gate before (left) and after (right) works

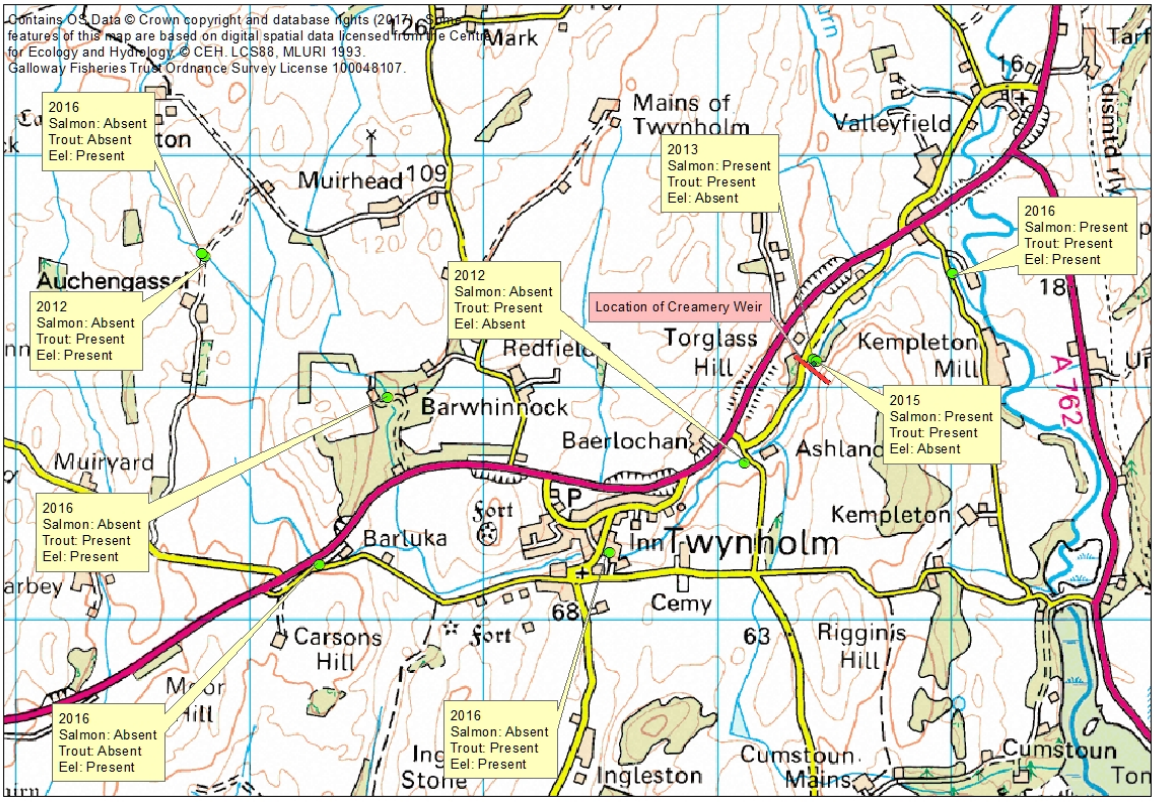
Figure 2: Creamery Weir before (left) and after (right) demolition works

A range of native fish species, including Atlantic salmon, sea trout, sea lamprey and river lamprey, can now return and live once again in the 10 km of good habitat available to them upstream of the weir site. Their return will ensure that a more natural ecosystem develops over time in the burn, particularly regarding a range of predator prey relationships.

4.2 Collection of electrofishing data

4.2.1 Collection of baseline electrofishing data

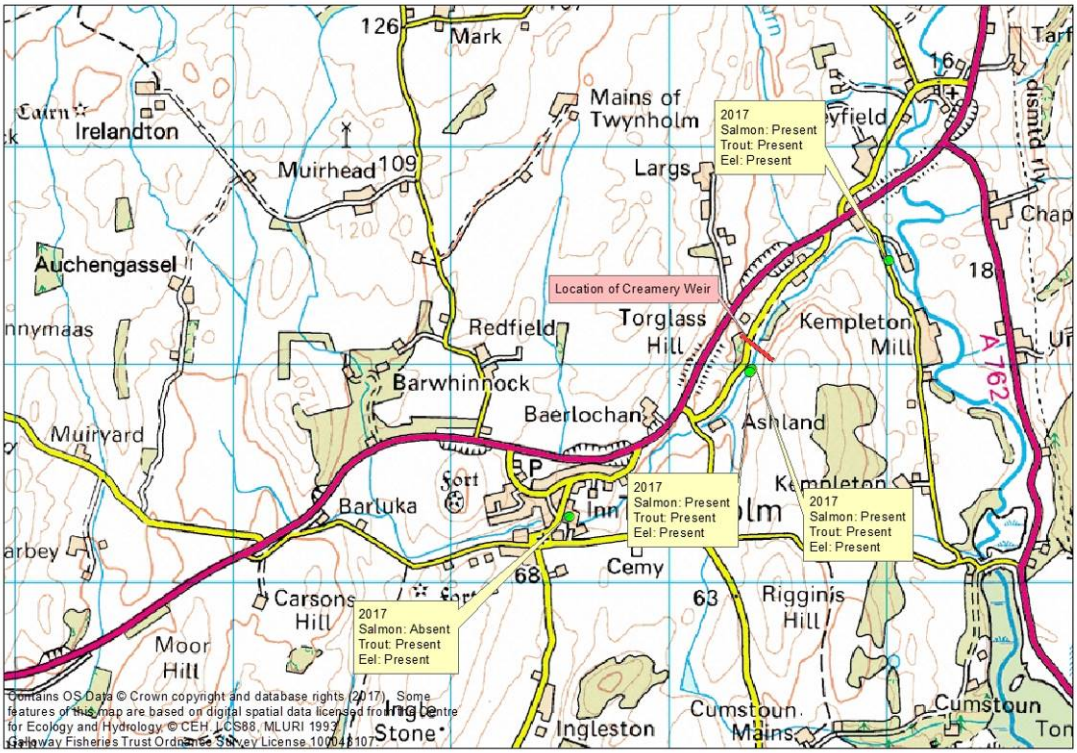
Between the years of 2012 and 2016, prior to any physical works taking place at the Creamery Weir site, nine sites were electrofished to gather baseline data on juvenile fish populations within the Old Mill Burn and watercourses draining into the burn (Kirk Burn and Auchengassel Burn). Appendix 2 details the results of these surveys. Presence/absence of fish species found within these sites can also be seen in Map 1. Salmon were found at only three sites (all downstream of the Creamery Weir site), generally in low fry and parr abundance except for during the 2013 survey when salmon fry were found in very high density a short distance downstream of the Creamery Weir. Trout were found at seven of the nine sites (located upstream and downstream of the Creamery Weir site), generally in low to moderate density except for trout fry - which were present in a high density a short distance downstream of the weir - in 2015, and trout parr – which were found in a high density upstream of the Creamery Weir within Twynholm - in 2016. Eels were found at six of the nine sites.



Map 1: Location map showing presence/absence of fish species within electrofishing sites surveyed on the Old Mill Burn prior to the removal of the Creamery Weir

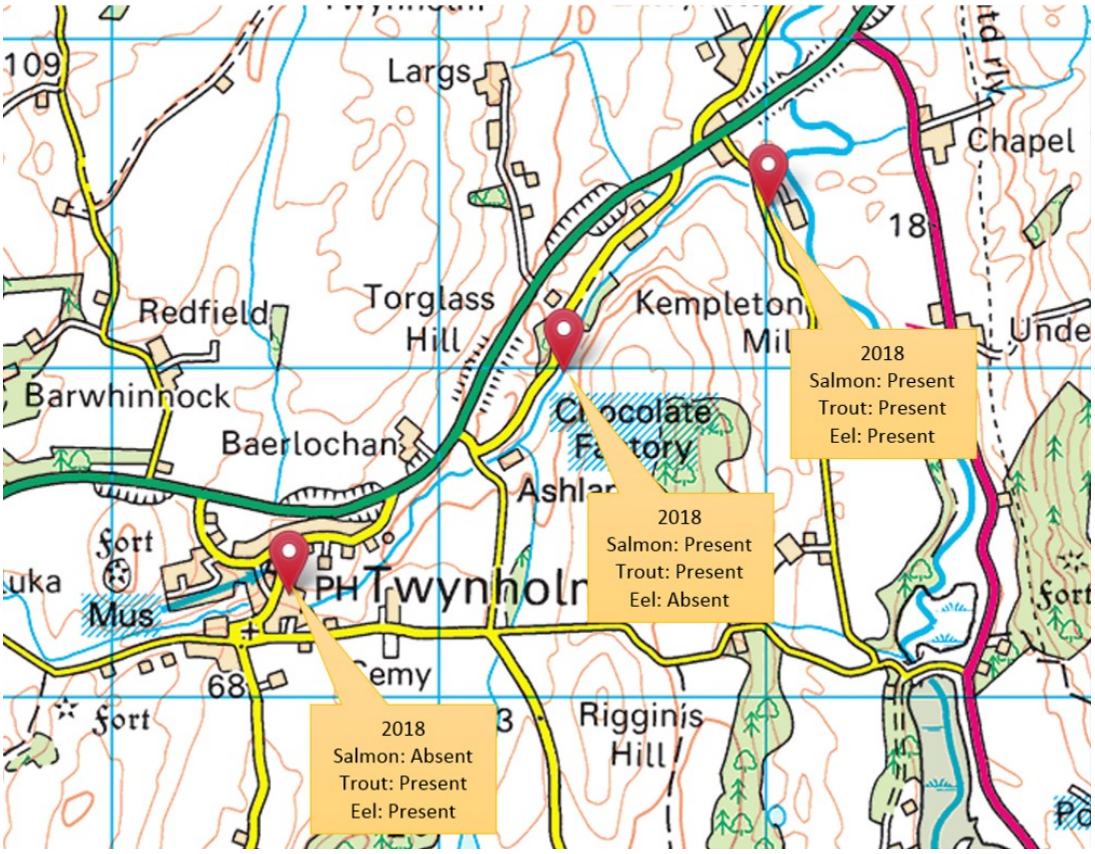
4.2.2 Collection of monitoring electrofishing data

In 2017, the first year of monitoring electrofishing was undertaken on the Old Mill Burn, to catalogue recovery of wild migratory fish populations to areas of the burn previously excluded by the Creamery Weir. Appendix 1 details the results of these surveys. Presence/absence of fish species found within these sites can also be seen in Map 2.



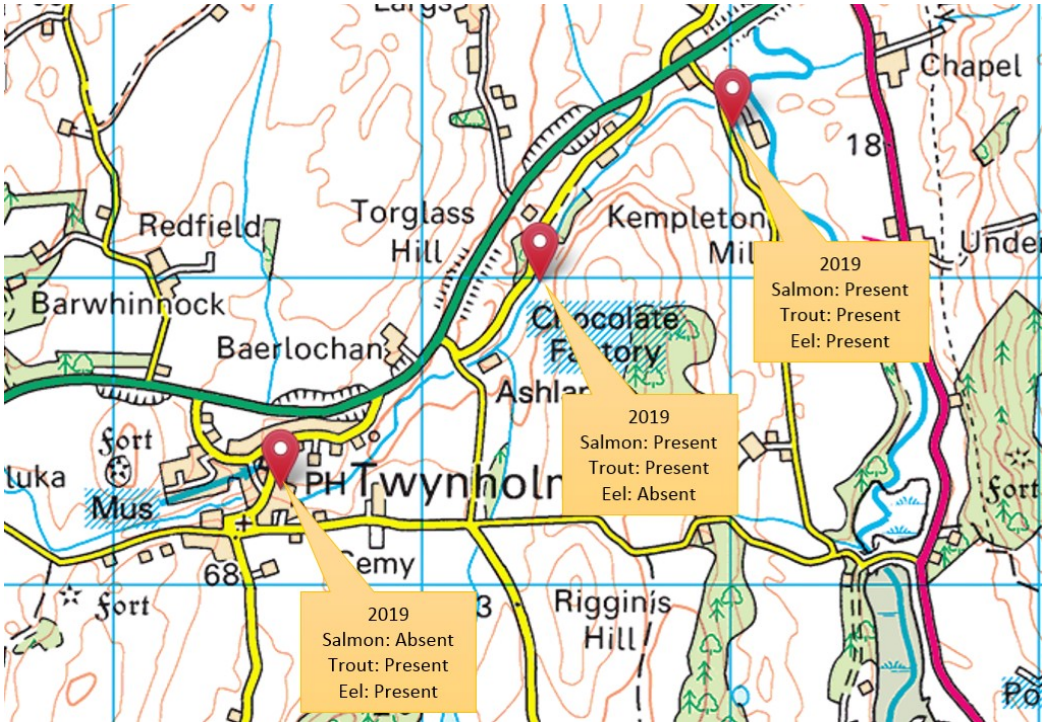
Map 2: Location map showing presence/absence of fish species within electrofishing sites surveyed on the Old Mill Burn following the removal of the Creamery Weir

In 2018, the second year of monitoring electrofishing was undertaken on the Old Mill Burn, to catalogue recovery of wild migratory fish populations to areas of the burn previously excluded by the Creamery Weir. Appendix 1 details the results of these surveys. Presence/absence of fish species found within these sites can also be seen in Map 3.



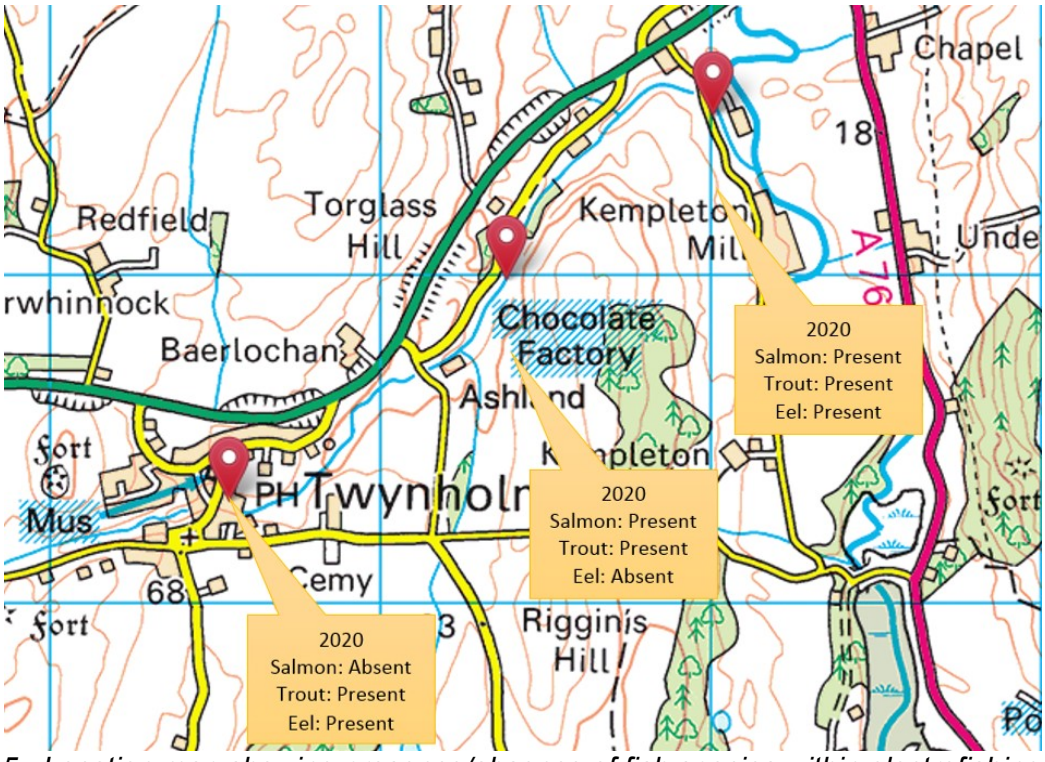
Map 3: Location map showing presence/absence of fish species within electrofishing sites surveyed on the Old Mill Burn following the removal of the Creamery Weir

In 2019, the third year of monitoring electrofishing was undertaken on the Old Mill Burn, to catalogue recovery of wild migratory fish populations to areas of the burn previously excluded by the Creamery Weir. Appendix 1 details the results of these surveys. Presence/absence of fish species found within these sites can also be seen in Map 4.



Map 4: Location map showing presence/absence of fish species within electrofishing sites surveyed on the Old Mill Burn following the removal of the Creamery Weir

In 2020, the fourth year of monitoring electrofishing was undertaken on the Old Mill Burn, to catalogue recovery of wild migratory fish populations to areas of the burn previously excluded by the Creamery Weir. Appendix 1 details the results of these surveys. Presence/absence of fish species found within these sites can also be seen in Map 5.



Map 5: Location map showing presence/absence of fish species within electrofishing sites surveyed on the Old Mill Burn following the removal of the Creamery Weir

4.2.2.1 Site 1: Old Mill Burn at Twynholm

Site 1 (Figure 3) was electrofished in an area of the burn previously surveyed in 2016 as part of baseline data collection, downstream of a road bridge in the village of Twynholm, adjacent to Hayton Coulthard offices. Water depth was shallow throughout the site (100% less than 30 cm deep). Substrates were recorded as consisting mostly of pebbles (40%), cobbles (30%), gravel (10%), boulders (10%) and silt (10%). Although substrates were felt to be mostly stable and uncompacted, some silt was released within the site when the bed was disturbed underfoot. This is likely to have resulted from the outflow of a large road drainage pipe that enters the burn immediately beneath the road bridge. Due to the low gradient nature of the site, shallow glide was the predominant flow type recorded as well as some run and riffle, within the upstream and downstream reaches of the site. Bankside cover was sparse, since both banks were constructed of vertical stone walls. However, some additional rocks overhanging the left bankside provided good cover. A small amount of vegetation (10%) in the form of brambles and ferns were found to overhang both banks. Tree cover was only present in the very lower reach of the site where mature elm branches overhung the site from the left bankside.

Figure 3: Site 1, looking upstream towards the bridge

2018:

A site length of approximately 30 m and channel width 1.2 m, was fished, mostly along the left bankside, beginning beneath some mature ash trees and finishing upon a break downstream of the bridge. A timed electrofishing survey of five minutes was undertaken at this site. Salmon fry and parr remain undetected at this site following the removal of the Creamery Weir downstream. Trout were present within the site at catch per unit efforts (CPUE) of 6.2 (fish/min) trout fry and 1.8 (fish/min) trout parr were recorded. One eel and two stoneloach were the only other fish species present at this site.

2019:

A site length of approximately 20 m and channel width 2 m, was fished, mostly along the left bankside. A timed electrofishing survey of five minutes was undertaken at this site. Salmon fry and parr remain undetected at this site following the removal of the Creamery Weir downstream. A healthy trout population was present within the site at catch per unit efforts

(CPUE) of 8 (fish/min) trout fry and 1 (fish/min) trout parr were recorded. No other fish species were recorded.

2020:

A site length of approximately 10 m and channel width 3 m, was fished, along both banks. A timed electrofishing survey of five minutes was undertaken at this site. Salmon fry and parr remain undetected at this site following the removal of the Creamery Weir downstream. A healthy trout population was present within the site at catch per unit efforts (CPUE) of 8.2 (fish/min) trout fry and 2.2 (fish/min) trout parr were recorded. One eel and stoneloach were encountered.

4.2.2.2 Site 2: Old Mill Burn upstream of Creamery Weir site

Site 2 (Figure 6) was situated on the Old Mill Burn, a short distance upstream of the demolished Creamery Weir. The site was reached through a gateway from the road side. This site was selected due to its holding faster flow types, shallow water depths and varied substrates i.e. being the most likely area to support juvenile salmon if they were at all present in this area of the burn.

Depth of water was shallow with 70% found to be less than 20 cm deep. Water flow was largely fast-flowing riffle and run flow type. Some shallow glide was also present. Substrates consisted of a good mixture of spawning material (50% cobble, 30% pebble and 15% gravel). Some densely packed silt material was also observed along the left bankside. Until recently, a ford and watering access point for cattle lay immediately upstream of the site. The right bankside is now completely fenced off and no livestock were observed accessing the burn. Vegetation has become established on this bank and now provides overhanging cover for fish across 30% of the right bankside. Land use surrounding the site was recorded as arable on the right bankside. Mature broadleaved trees line the roadside along the left bank, 10 m from the burn. It is possible there is a degree of eutrophication within the burn as a result of the outflow from Twynholm sewage works upstream, which would explain the faint green colouration of the water observed on the day of the survey.

Figure 6: Looking upstream at site 2

2018:

A site length of approximately 60 m and channel width 1.2 m, was fished up the middle of the channel. A timed electrofishing survey of five minutes was undertaken at this site. Salmon were present within the site at catch per unit efforts (CPUE) of 1.8 (fish/min) salmon fry and 1 (fish/min) salmon parr were recorded. Trout were present within the site at catch per unit efforts (CPUE) of 6.2 (fish/min) trout fry and 1.8 (fish/min) trout parr were recorded. Stoneloach were the only other fish species present at this site.

2019:

A site length of approximately 40 m and channel width 2.8 m, was fished up the middle of the channel. A timed electrofishing survey of five minutes was undertaken at this site. Salmon were present within the site at catch per unit efforts (CPUE) of 0.4 (fish/min) salmon fry and 0.4 (fish/min) salmon parr were recorded. Trout were present within the site at catch per unit efforts (CPUE) of 2.2 (fish/min) trout fry and 0.4 (fish/min) trout parr were recorded. No other species were recorded at this site.

2020:

A site length of approximately 30 m and channel width 2 m, was fished up the middle of the channel. A timed electrofishing survey of five minutes was undertaken at this site. Salmon fry were present within the site at a catch per unit effort (CPUE) of 1.6 (fish/min). No salmon parr were recorded. Trout were present within the site at catch per unit efforts (CPUE) of 8.2 (fish/min) trout fry and 0.8 (fish/min) trout parr were recorded. No other species were recorded at this site.

4.2.2.3 Site 4: Old Mill Burn – adjacent to Sandy Brae

Site 4 (Figure 9) was electrofished in an area of the burn previously surveyed in 2016 as part of baseline data collection, downstream of a road bridge through a field adjacent to Sandy Brae. This site was located downstream of the Creamery Weir site. Water depth was shallow throughout the site (80% less than 30 cm deep). Substrates were recorded in equal measures of gravel, pebble and cobble (30-35%). Some boulders were also present and provided good instream cover. In general, flow types were recorded as run/riffle (70%) mid-channel and as shallow and deep glide with a small amount of pool (trout habitat) along the banksides. Bankside cover was provided by overhanging vegetation on 70% of the left bankside (mowed grass began over 5 m back from this bankside) and 20% of the right bankside. Broadleaved trees (mostly elm) provided cover across 40% of the right bankside and overall, 15% canopy cover spanned the entire site.

Figure 9: Looking upstream at site 4

2018:

A site length of approximately 40 m and channel width 1 m, was fished up the right bankside. A timed electrofishing survey of five minutes was undertaken at this site. Salmon were present within the site at catch per unit efforts (CPUE) of 3.4 (fish/min) salmon fry and 0.6 (fish/min) salmon parr were recorded. Trout were present within the site at catch per unit efforts (CPUE) of 4 (fish/min) trout fry and 0.6 (fish/min) trout parr were recorded. One eel and stoneloach were the only other fish species present at this site.

2019:

A site length of approximately 40 m and channel width 1.4 m, was fished up the middle of the channel. A timed electrofishing survey of five minutes was undertaken at this site. Salmon fry were present within the site at a catch per unit effort (CPUE) of 1.6 (fish/min). Salmon parr were absent from this site. Trout were present within the site at catch per unit efforts (CPUE) of 1.4 (fish/min) trout fry and 0.2 (fish/min) trout parr were recorded. Two eels were present alongside minnow and stoneloach.

2020:

A site length of approximately 45 m and channel width 1.4 m, was fished up the right bankside. A timed electrofishing survey of five minutes was undertaken at this site. Salmon were present within the site at catch per unit efforts (CPUE) of 1.8 (fish/min) salmon fry and 0.6 (fish/min) salmon parr were recorded. Trout fry were present within the site at a catch per unit effort (CPUE) of 0.6 (fish/min). Two eels were present alongside minnow and stoneloach.

5. APPENDIX 1: RESULTS FROM MONITORING ELECTROFISHING SURVEY COMPLETED ON THE OLD MILL BURN, POST-WORKS YEARS 2-4 (2018, 2019, 2020)

Site Code	Year	Watercourse	Site Location	Grid Ref	Survey Date	Presence Of Other Species*	Catch per unit effort (number of fish caught per minute)			
							Salmon Fry (0+)	Salmon Parr (1+ and older)	Trout Fry (0+)	Trout Parr (1+ and older)
DTK1		River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – in Twynholm	266540 554307	01/08/2018	E, SL	0	0	6.2	1.8
					25/07/2019		0	0	8.2	2.2
					13/08/2020	E, SL	0	0	8.2	2.2
DTK3		River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – through gateway	267370 554970	01/08/2018	SL	1.8	1	14.6	0.8
					25/07/2019		0.4	0.4	2.2	0.4
					13/08/2020		1.6	0	8.2	0.8
DTK4		River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Downstream of Creamery Weir site – adjacent to Sandy Brae	268006 555482	01/08/2018	E, SL	3.4	0.6	4	0.6
					25/07/2019	E, SL, M	1.6	0	1.4	0.2
					13/08/2020	E, SL	1.8	0.6	0.6	0

6. APPENDIX 2: RESULTS FROM YEAR ONE MONITORING ELECTROFISHING SURVEY COMPLETED ON THE OLD MILL BURN, YEAR ONE POST-WORKS, 2017

Site Code	Watercourse	Site Location	Grid Ref	Survey Date	Presence Of Other Species*	Area Fished (m²)	Density per 100 m² ** or fish/min (timed electrofishing)			
							Salmon Fry (0+)	Salmon Parr (1+ and older)	Trout Fry (0+)	Trout Parr (1+ and older)
DTK1	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – in Twynholm	266540 554307	01/09/17	E, SL		0	0	6.8/min	0.2/min
DTK2	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – through gateway	267380 554982	31/08/17	E	56.2	>24	0	>56	0
DTK3	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – through gateway	267370 554970	31/08/17	E, SL		2.2/min	0	9.4/min	0.2/min
DTK4	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Downstream of Creamery Weir site – adjacent to Sandy Brae	268006 555482	01/09/17	SL, M		3.6/min	0	2/min	0

* E = Eel, SL = Stoneloach, M = Minnow

** Where a Zippin calculation could be carried out, 95% confidence limits are shown. Where only the number appears, a Zippin estimation could not be carried out. In these cases the number represents a minimum estimate of fish density per 100 m^2 of water.

7. APPENDIX 3: RESULTS FROM PRE-WORKS ELECTROFISHING SURVEYS COMPLETED ON THE OLD MILL BURN AND TRIBUTARIES DRAINING INTO, 2012-2016

Site Code	Watercourse	Site Location	Grid Ref	Survey Date	Presence Of Other Species*	Area Fished (m²)	Density per 100 m² **			
							Salmon Fry (0+)	Salmon Parr (1+ and older)	Trout Fry (0+)	Trout Parr (1+ and older)
N/A	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn, Auchengassel Burn	Upstream of Creamery Weir site – downstream of bridge	264807 555568	24/09/12	E, SL	58.5	0	0	0	>5
N/A	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – upstream of bridge at Ashland	267112 554678	24/09/12	-	83.0	0	0	>12	>2
N/A	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Downstream of Creamery Weir site	267407 555125	18/02/13	-	27.2	>51	>3	>7	0
N/A	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Downstream of Creamery Weir site	267420 555120	14/10/15	E	47.0	0	>4	>44	>4
DKB1	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Downstream of Creamery Weir site – adjacent to Sandy Brae	268003 555496	19/07/16	E	89.6	>4	>1	>10	>3
DKB2	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn, Auchengassel Burn	Upstream of Creamery Weir site – downstream of bridge	264793 555581	19/07/16	E, SL	45.3	0	0	0	0
DKB3	River Dee (Kirkcudbrightshire) Tarff Water, Old	Upstream of Creamery Weir site – downstream of Damhill	265296 554240	19/07/16	E, SL	32.3	0	0	0	0

	Mill Burn, Kirk Burn	Bridge								
DKB4	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn	Upstream of Creamery Weir site – downstream of bridge in Twynholm	266536 554293	19/07/16	E, SL	64.7	0	0	>3	>13
DKB5	River Dee (Kirkcudbrightshire) Tarff Water, Old Mill Burn, Kirk Burn	Upstream of Creamery Weir site – upstream of bridge at Barwhinnock	265586 554960	19/07/16	E, SL	60.5	0	0	0	>1

* E = Eel, SL = Stoneloach, M = Minnow, Pi = Pike, Pe = Perch

** Where a Zippin calculation could be carried out, 95% confidence limits are shown. Where only the number appears, a Zippin estimation could not be carried out. In these cases the number represents a minimum estimate of fish density per 100 m^2 of water.