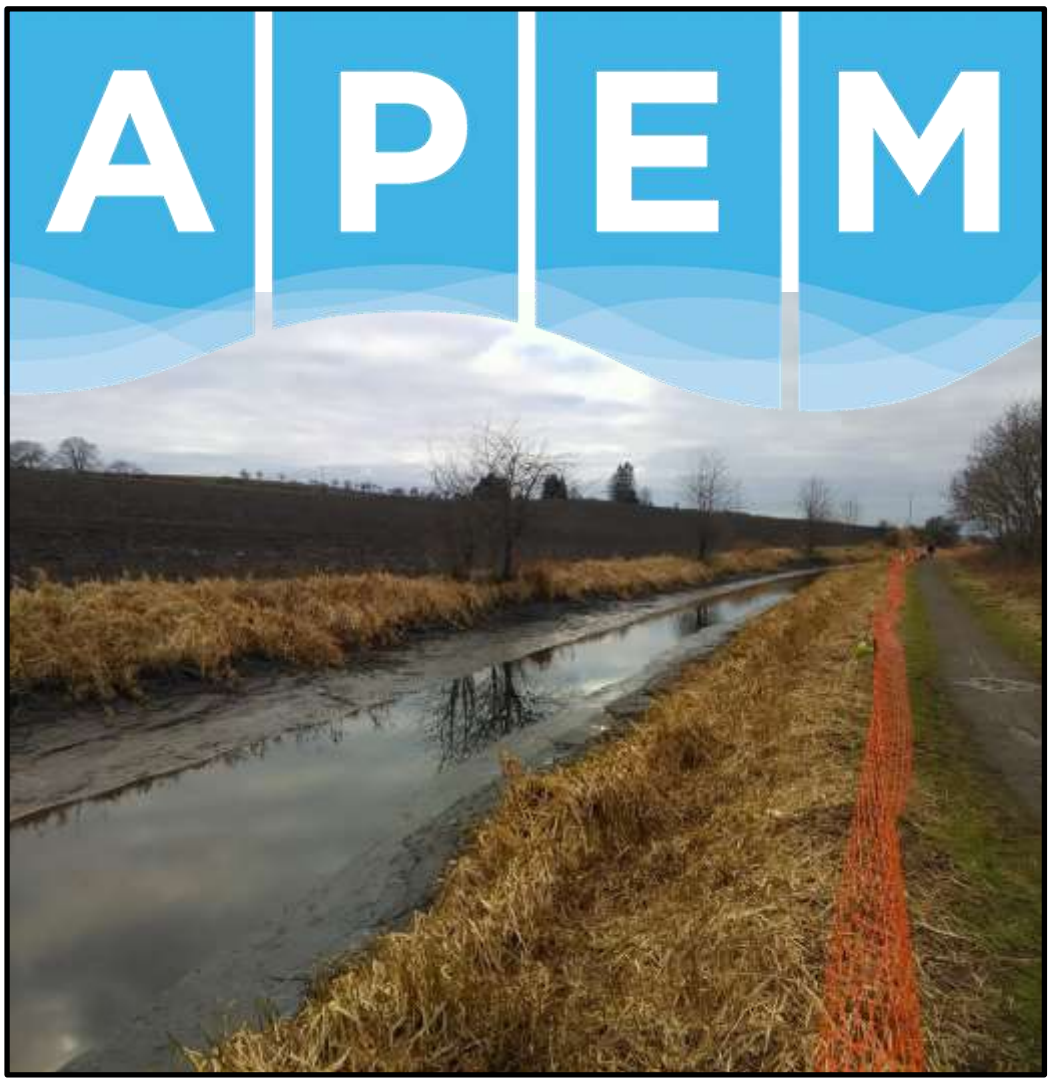

Union Canal Fish Relocation Operation

Scottish Canals

APEM Ref: P0001383

May 2017

Peter Dennis M.Sc. MIFM

Client:	**Scottish Canals**
Address:	**Scottish Canals** **Canal House,** **1 Applecross Street,** **Glasgow** **G4 9SP**
Project reference:	**P00001383**
Date of issue:	**May 2017**

Project Director:	**Peter Dennis**
Project Manager:	**Joseph Allaby**

APEM Ltd
A17 Riverview,
Embankment Business Park
Heaton Mersey,
Stockport
SK4 3GN

Tel: 0161 442 8938

Registered in England No. 2530851
Website: www.apemltd.co.uk

Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
V1	13.05.2017	ALL		Inclusion of additional surveys	PD

Contents

1. Introduction

In 2017, Scottish Canals (SC) planned to undertake essential engineering work on 5050m of the Union Canal in Linlithgow, West Lothian. The canal is designated as a Cyprinid (Coarse) fish water under the European Directive on Freshwater Fisheries and provides a valuable amenity to the local community along with boaters, walkers and tourists in and around the Linlithgow area. The canal has also historically provided a valued commodity to anglers, with the fishery managed by the SC & Scottish Federation for Coarse Angling's partnership which covers the entirety of the Forth & Clyde and Union Canal network.

In order to facilitate access to the canal infrastructure for engineering activity, the system was partially dewatered between bridge 42 in Wilcoxholme and bridge 48 in Woodcockdale in January & February 2017 (Fig.1.1). The dewatering was undertaken over a 2 week period and was controlled by pumps at bridge 48 and by subterranean discharge from the bed valve at Woodcockdale.

APEM were commissioned to capture the fish from the dewatered reach of the canal and relocate them to reaches unaffected by the work, whilst collating the details of the catch for subsequent analysis of the condition of the stock. Whilst the canal was dewatered APEM also undertook a series of surveys for zebra mussels, freshwater sponges and crayfish using a team of licensed specialists.

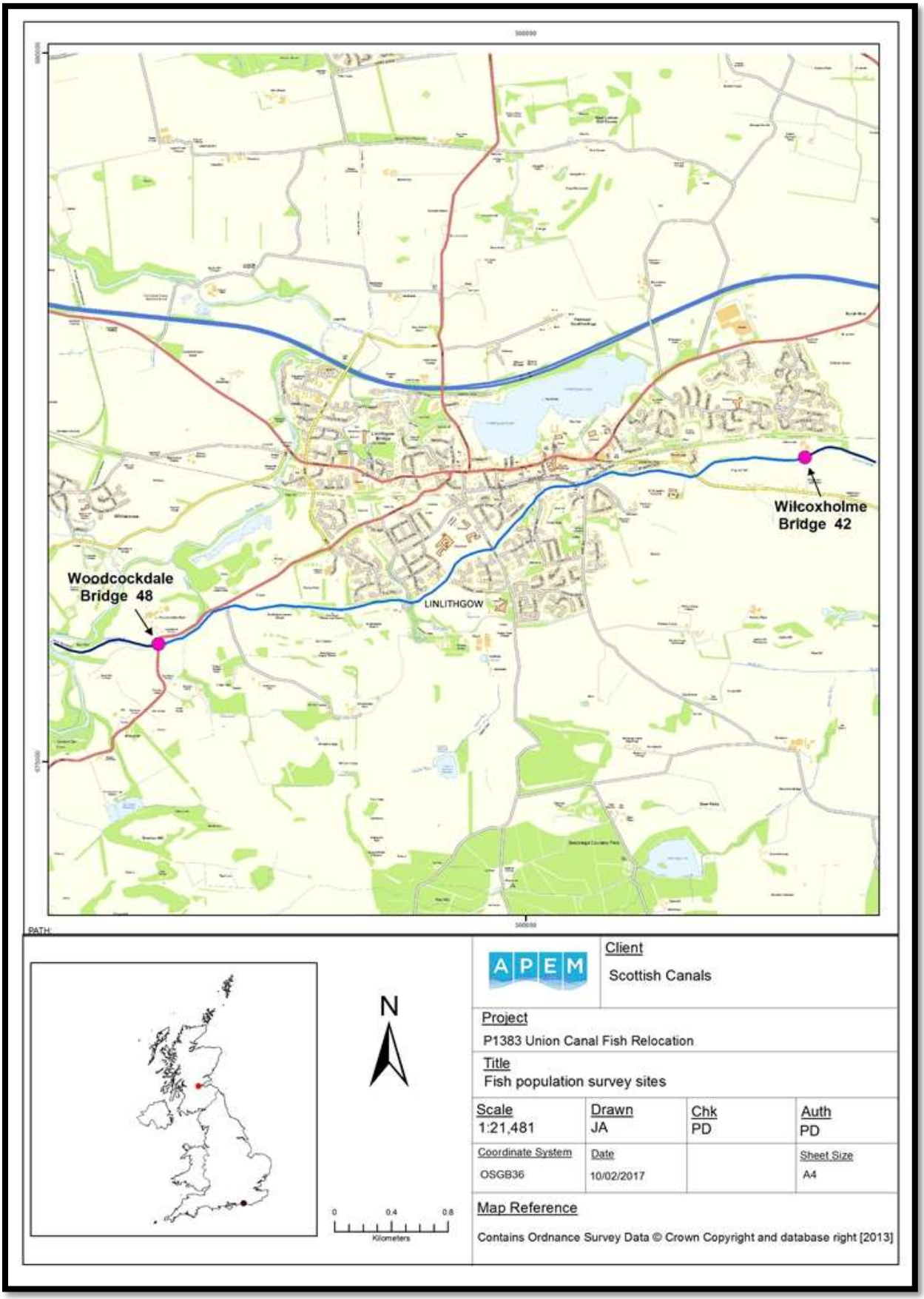

Figure 1.1. Location of the dewatered reach of the Union Canal between Bridges 48 & 42, in Linlithgow.

2. Methods

By January 16th 2017 the Union Canal between Bridge 42 & 48 had been drained down to a level suitable for the fish relocation process to start. As the efforts to capture the fish progressed the water level was continuously lowered in order to optimize efficacy and to ensure >90% of the fish in the affected reach were relocated. The level of the water in the canal was managed during dialogue between the SC site operation team and the APEM field team leader (Peter Dennis).

2.1 Fish capture and relocation

Electric fishing was deemed to be the most suitable method to capture the fish in the dewatered reach of the canal and was undertaken by 2 operatives either wading or sitting on an inflatable boat. The team used a double anode arrangement with bankside electracatch equipment set up in a boat. The power delivered to the water was overseen by a third person, who also acted to push the vessel along the canal (Fig 2.1). The electric field was applied continuously in order to stun any fish within the field of the anodes, with shoaled fish corralled towards stop nets which split the dewatered canal into appropriately sized pounds (approximately every 500m).

Figure 2.1. Wading and boat based approach to the capture of fish on the Union Canal

All fish captured were held in tanks before being identified to species, enumerated, inspected for signs of parasitism, measured (fork length) to the nearest mm and bulk weighed to species. Any eels captured were held in separate enclosures as mucus secreted by eels can be toxic to other freshwater fish. After processing, all fish were allowed to recover satisfactorily before being transported into specialist 1000L fish holding facility on

the back of an APEM 4X4 vehicle. These fish were then transported to the adjacent sections of canal unaffected by the works by a dedicated team of 'runners' operating from the tow path or other access locations. The transferal and overall husbandry of the fish stock removed from the canal followed best practice, which was especially pragmatic given the interest of the general public and local press.

In order to ascertain the overall fish population density in each pound it was hoped that a number of electric fishing runs could be performed at each site, with catch depletions inferring an eventual estimate of population density. However, the substrate conditions at each of the survey sites were such that after the survey team had entered the water fine particulates occupied the water column and failed to settle immediately. As such, only single runs were undertaken within each enclosure on each day, although the total reach of 5050m was covered on numerous separate occasions between the 16th & 25th January and in order to maximize catch efficiency.

All electric fishing was conducted by professionals trained under the Environment Agency Electric Fishing Code of Practice and using equipment that complies with Annex A & B, Issue II Specification of that code.

2.2 Crayfish Survey

Unlike the rest of Britain, Scotland has no native crayfish species, although both white-clawed and North American signal crayfish have both been recorded in recent years. Signal crayfish were first reported in the 1990's and now occupy a number of catchments in Scotland, where it is considered a significant threat to native biodiversity. The spread of signal crayfish via the canal network in Scotland has been raised as a concern and as such SC commissioned APEM to undertake a presence / absence survey during the engineering activity in the Linlithgow reach. The aim of the survey was to understand the current distribution and potential for future colonisation of crayfish in the Union Canal

A manual search using the Standard Method (Peay, 2003) was used during the survey with timed searches of suitable crayfish habitat performed at each site. A continuous search of five habitat patches was performed within a 500 m survey reach with the clock only stopped for processing any crayfish caught. The number of refuges searched was recorded to provide an indication of search effort (in addition to time). To further maximize the chance of identifying crayfish, baited Fladen traps were deployed overnight in the deeper waters of the canal where manual searches could not be undertaken. If caught, the length and sex of the crayfish was recorded along with a general condition assessment including any evidence of disease.

2.3 Zebra Mussel Survey

The zebra mussel is an established invasive non-native species (INNS) whose range and abundance has been increasing since the 1990s. Zebra mussels attach themselves to substrate and therefore require hard, stable surfaces in order to persist. They are normally associated with still or slow flowing waters – lakes, reservoirs and canals – as they disperse via a free living larval stage (the veliger) that is susceptible to being washed downstream in river environments. Once in an aquatic system, their growth form can cause structural alterations to river bed habitats and cause serious biofouling which is a major problem for water companies. Their high filtration rates can also reduce availability of food resources for other invertebrates, and they can smother other native species. Of particular concern is the apparent ability of zebra mussel to facilitate spread and survival of populations of 'killer shrimp' (*Dikerogammarus villosus*). It is for these reasons that zebra mussels are classified

as a high impact species with respect to Water Framework Directive Habitat assessment and SC have taken the decision to perform a presence / absence survey during the engineering activity on the Union Canal.

The field surveys took place on 9th & 10th February 2017 and were conducted during the crayfish trap deployment. The team started at Woodcockdale Bridge and moved east to Wilcoxholme Bridge. Prior to the survey, and following standard APEM protocol, all equipment (including footwear) was disinfected and dried to ensure that there was no accidental contamination from previous fieldwork activities; this process was repeated at the end of the survey, with all footwear, nets and equipment that came into contact with the watercourse being thoroughly disinfected before leaving the site.

As the surveyors moved along the canal, all hard structures within the water were identified, including dock walls, bridges, culverts, debris and dead wood. Once a potential hard attachment surface for zebra mussels was identified, it was carefully searched with 0.25m^2 quadrat held again the substrate. The method also included a hand search for undersides of structures and other less visible features. Hard surfaces in deeper water were also scraped using a long handled hand net. During this survey the team also visually inspected hard surfaces for freshwater sponges which in spite of their ecological importance have been relatively uninvestigated in Scotland. Freshwater sponges are excellent indicators of water and ecosystem quality, which abundant populations suggesting good water quality.

2.4 Consent and licensing

In order to use the recommended methods APEM applied for consent use the equipment, (including Fladen crayfish traps) from Marine Scotland and Scottish Natural Heritage. The application was also supplemented by discussions with the Forth District Salmon Fishery Board.

The license for the work was granted on January 6th and was passed to APEM with a number of conditions relating to biosecurity and invasive species control, notably the prerequisite that (if encountered) no ruffe should be returned to any reaches of the watercourse. A tank for humane euthanasia of ruffe was therefore set up if this requirement arose during the work.

2.5 Biosecurity

Biosecurity awareness and mitigation measures to control spread of disease were adopted even if disease or invasive non-native species were not immediately apparent on the Union Canal. As a precautionary measure, to minimise the risk of transmitting disease or spreading non-native species, disinfection procedures were followed during the fish relocation, with all nets, PPE and auxiliary equipment treated both before and after the exercise. APEM's codes of practice for disinfection are set up for this purpose with all disinfection procedure following DEFRA, CEFAS, Natural England and Forestry Commission guidelines.

3. Results

A total of 5 passes of the 5050m dewatered reach of the canal were undertaken under ideal climatic conditions with little or no precipitation. The canal remained unfrozen and the physicochemical conditions of the canal water remained suitable for the duration of the work. It is thought that the canal in the affected reaches covered an overall area of approximately 40400m^2 (4.04ha), which included bays and docks within its footprint.

3.1 Fish Population & Density

In total, 2534 fish were safely captured and relocated during the exercise, comprising of 5 species (Table 3.1). It is anticipated that this catch was relocated in equal proportions between the 2 drop off points at Woodcockdale and Wilcoxholme.

Table 3.1. Combined catch from the dewatered reach (5050m) of the Union Canal.

Species	Size range (mm)	Weight range (g)	Total Catch
Roach	40-288	1-875	1829
Perch	30-220	1-820	557
Pike	155-705	20-4020	103
Eel	280-640	80-750	30
Brown Trout (Incl. sea trout)	105-705	30-2650	15
Total			**2534**

Roach were the most abundant fish in the reach contributing 72% of the total catch, with perch the second most abundant contributing 22% of the overall number of fish relocated during the exercise (Figure 3.1). Numerically, pike, eels and brown trout (including sea trout) were the least abundant species with their combined catch contributing just 6% of the overall catch. However, the latter 3 species contributed a significant proportion of the total biomass relocated from the reach with a higher average size and weight when compared to roach and perch (Table 3.2).

Table 3.2. Fish species population density in the sampled reach (40400m^2) of the Union Canal.

Species	Minimum Population Density (m^2)	Biomass (kg/ha)
Roach	0.045	22.6
Perch	0.014	2.8
Pike	0.003	5.1
Eel	0.001	1.5
Brown Trout (Incl. sea trout)	<0.001	0.9
Overall		**32.9**

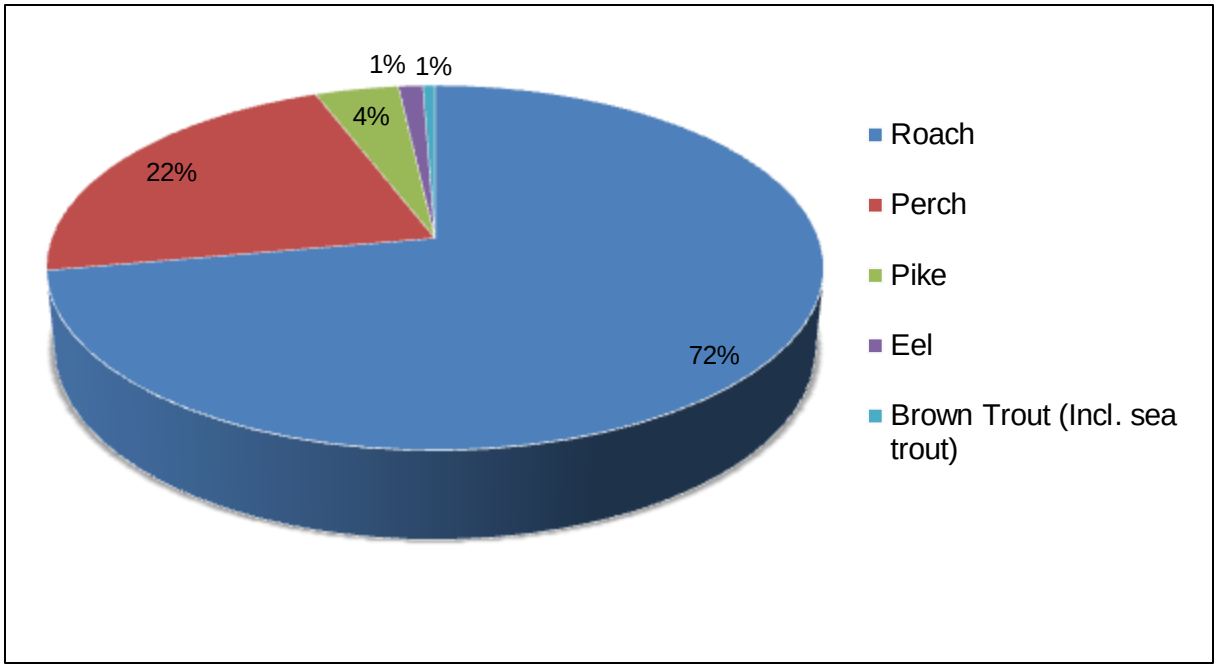

Figure 3.1. Species contribution of the combined catch from the dewatered reach of the Union Canal in Linlithgow.

The overall biomass of the reach of the Union Canal assessed was approximately 33kg/ha, with roach contributing approximately 70 % of this catch. This stock was generally evenly spread throughout the entire reach, although 'pockets' of fish were reported in the deeper areas and where cover was most prevalent (this may be due to the effect of the fish stock congregating as the water levels lowered).

Due to the efficacy of the method used and the number of electric fishing runs performed in each pound (which showed a clear depletion in the numbers each time) it is thought that the majority (>95%) of the fish stock in the reach was relocated during the exercise. This may not be the case for the eel population due to their capability to seek refuge in the deep sediment of the canal and thus evade capture therefore they may be present in higher numbers. However, it is thought that these individuals will be able to tolerate the conditions of the drawn down canal and thus survive until the canal is rewatered.

3.2 Population Demographic

The range in size of all species captured suggests that a number of year classes were represented in the fish stock of the Union Canal. This was notably the case for roach which are thought to have at least 5 year classes represented in the catch (Fig. 3.2). A number of large adult roach thought to be older than 5 years were safely relocated, notably in the wilcoxholme reach (Fig. 3.3).

Large numbers of 0+ (young of the year) perch were relocated during the work with shoals congregating around marginal linear emergent macrophyte stands. This suggests a very successful year for perch in 2016/ 17. However, very few of the perch relocated were larger than 200mm.

The brown trout catch included a range of age classes, including a number of juveniles (thought to 1+ fish) suggesting good water quality and potential connectivity to freshwater streams in the catchment.

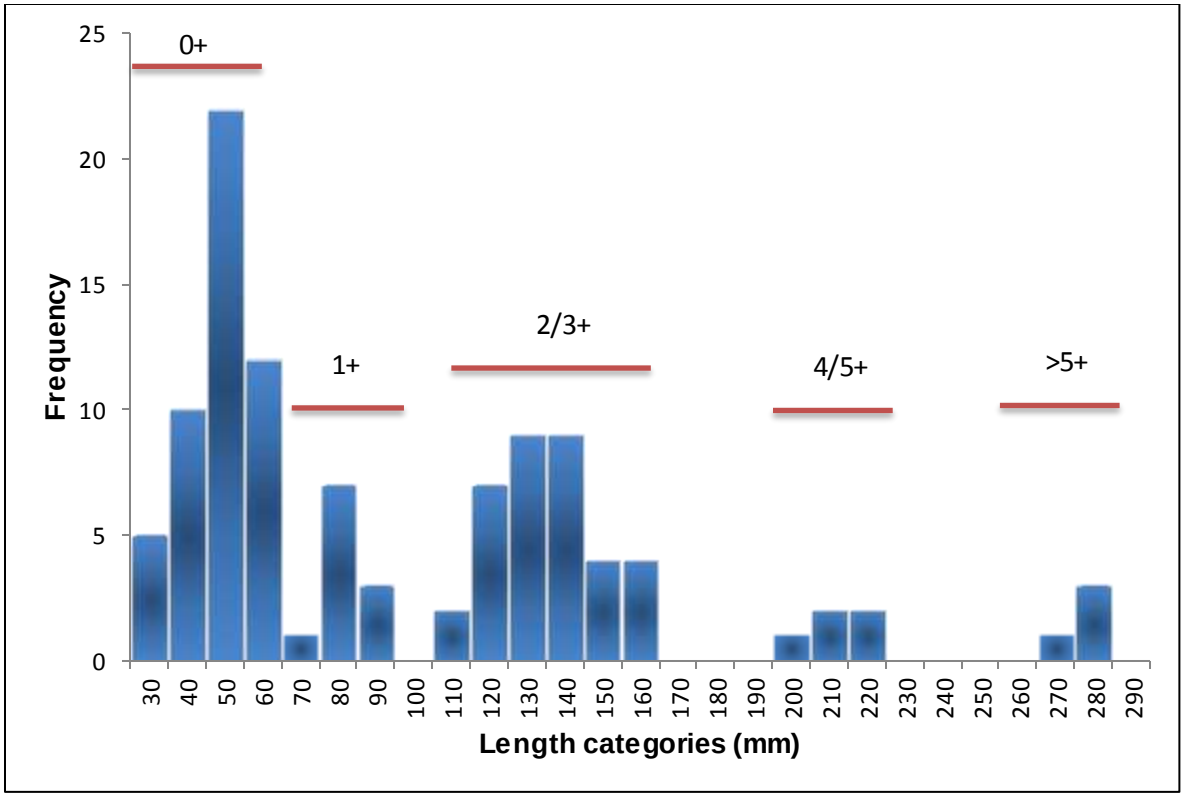

Figure 3.2. Length frequency distribution and estimated age structure of roach from the dewatered reach of the Union Canal on 18th January 2017.

Figure 3.3 Adult roach captured and relocated in the pond adjacent to Bridge 42

3.3 Conservation species

The only conservation species encountered during the fish relocation on the Union Canal were eels which were present in low numbers throughout the dewatered reach. Although present in relatively low numbers (0.001 per m^2) the conservation status of eels is such that the population of the Union Canal is regionally important. Eels are not only considered a UK BAP Priority Species but are listed as critically endangered on the IUCN Red List and as such the Union Canal population must be robustly protected where ever possible.

The size range of the eel population in the Union Canal suggests that juveniles are capable of accessing the waterbody from the sea and growing to large reproductive age fish. The largest eel relocated during the work was 750mm and was silver, ready to return to the sea for migration (Figure 3.4)

Figure 3.4. Adult European eel relocated from the dewatered reach of the Union Canal.

3.4 Parasitology & Stock Health

The fish relocated were generally in good condition although some fish leech infestations were reported, notably on the larger pike. This is not uncommon during winter and reflects the sedentary nature of some fish species during colder water temperatures. Evidence of skin damage associated with predation attempts were reported on a number of fish.

3.5 Crayfish

Exhaustive manual surveys and baited trapping were undertaken at 7 locations throughout in the Lithlithgow reach of the canal. The locations where crayfish surveys were undertaken and traps set are provided in Table 3.3. These surveys resulted in no observations for any crayfish species.

Table 3.3. Location of crayfish surveys and resultant catch

Site (Bridge) no.	NGR	No. of Crayfish caught
42	NT0197177140	0
43	NT0042676951	0
44	NT0007676861	0
45	NS9975476500	0
46	NS9939276237	0
47	NS9789976087	0
48	NS9741675823	0

It must be noted that the recommended survey window for crayfish does not extend into February and as such the capture rate would be expected to be low. However, given the extent of the surveys and the incidental observations during the other components of the commission, evidence (e.g. shells, claws etc) would have been expected to be have been reported if crayfish were present.

3.6 Zebra mussels & Freshwater Sponges

A total of 20 sites were surveyed for zebra mussels and freshwater sponges on the Union Canal (Table 3.4). The walls of the canal were the primary areas searched with both the exposed and submerged areas assessed. In addition a range of other submerged substrates were sampled including debris and pontoons.

Although no zebra mussels were observed during the survey (and during the other ecological activities on the canal) a number of freshwater sponges were observed (Figure 3.5).These were all thought to be *Spongilla lacustris* which is a species of the freshwater sponge family *Spongillidae*. These sponges occupy lakes and canals across the UK and although relatively common are indicators of good water quality, being notably intolerant of organic pollutants.

The survey team also identified a number of swan mussels in the survey reach which were numerous in littoral areas of the canal where sediment and organic material had accumulated.

Table 3.4. Location of zebra mussel & freshwater sponge surveys and resultant catch

Site no.	NGR	No. of Sponges	No. of Zebra mussels
1	NT0197677140	2	0
2	NT0170877136	0	0
3	NT0146777130	0	0
4	NT0120677022	1	0
5	NT0095977046	0	0
6	NT0071577017	0	0
7	NT0042976955	1	0
8	NT0017276935	0	0
9	NS9998576749	2	0
10	NS9977976515	3	0
11	NS9950376389	0	0
12	NS9932476187	0	0
13	NS9905976140	0	0
14	NS9879976090	0	0
15	NS9853176085	0	0
16	NS9826576097	0	0
17	NS9800476083	0	0
18	NS9775376036	0	0
19	NS9757075874	0	0
20	NS9741675823	1	0

Figure 3.4. Freshwater sponge *Spongilla lacustris* identified in the Union Canal.

4. Discussion

The Union Canal provides a vital commodity to the local population in and around Linlithgow both in terms of its socioeconomic benefits as well as the biodiversity attracted to the wildlife corridor it creates. A crucial component of the aquatic life of the canal is the fish stock which provides sport for local anglers as well as a primary educational resource for local schools and education centers. As such, the strategic management the fish stock by Scottish Canals during engineering work on the canal is of importance from an ethical and public relations perspective.

The process of capturing and relocating the fish stock in the 5050m dewatered reach was undertaken as safely and expediently as the conditions allowed. Although the water levels in the canal were dropped slower than expected, the excellent access to the watercourse, via a newly constructed tow path, and good communication between the APEM and SC team onsite facilitated the transfer of fish without incident or the loss of any fish.

Upon final draw down to low water levels APEM were able to capture the remaining stock and relocate them safely with only a small number of eels, which would be tolerant of the conditions, thought to be left in the reach.

Overall the fish stock encountered during the relocation process was typical of Scottish canal networks, with the population dominated numerically by roach and perch, eels and pike. No larger cyprinds were encountered (e.g. carp, bream, tench) although a number of brown trout, including a small number of larger fish thought to be sea trout, were captured and safely relocated.

The population density of all fish species was lower than previously encountered during comparable works undertaken by APEM on behalf of British Waterways in 2006 & 7. Here a biomass of approximately 100kg/ha was encountered, with the number of adult fish higher across all species. The stock in the Linlithgow reach was approximately 33% of this figure (32.9kg), which could be attributable to more diverse habitat in the reaches lower in the system, notably in the Falkirk Wheel basin, where a larger expanse of water and more diverse habitat allows more successful breeding conditions.

The demography of the fish population captured suggests that the resident fish are present in a range of age classes, including to reproductive age in all species. Cohorts to the 2016/17 year class appeared to be good with numerous 0+ juveniles of all species recorded (except eels). However, the numbers of fish in the expected adult size range was generally lower than expected, with very few mature adult roach and perch captured.

Although the water quality of the canal (indicated by physico-chemical condition) was thought to be mostly good, with high dissolved oxygen recorded at a number of sites between Bridges 42 & 48, the habitat diversity was low throughout the reach with homogenous littoral conditions, typical of canal systems. In addition, benthic sediment accumulations were extremely deep in places (>500mm). It is thought that the organic-rich nature of this material may place a burden on the dissolved oxygen concentrations of the canal water, notably once water temperatures increase during summer months. A number of discharges into the canal were also observed including surface run off from carparks and residential developments, which could periodically affect the quality of the water.

The generally low fish population density and biomass encountered in the Linlithgow reaches of the Union Canal may be attributable to a number of pressures on the population, including the homogeneous aquatic habitat of the canal (limiting spawning and nursery

functionality), potentially poor physico-chemical conditions in summer months (limiting growth and variety of food resource for fish) and other anthropogenic pressures relating to the semi urban nature of the watercourse. However, the predation pressure on the fish population notably by birds species is thought to be the most likely reasons for the relatively low population densities experienced (cormorants, gulls and goosanders were all observed during the fish relocation process). The skin and fin damage reported on a number of the adult fish, notably roach, is consistent with avian predation attempts and may explain the lower than expected numbers of adult individuals across all species.

The apparent absence of crayfish and zebra mussels in the 5050m reach of the Union Canal in Linlithgow suggests that these species have not colonized this extent of the canal. Further work is required to ascertain if they have entered the network elsewhere and all measures should be employed to prevent the spread of all invasive species into the Scottish canal system.

The abundance of freshwater sponges in the Union Canal suggests that they are well distributed in the canal network in Scotland. This suggests that the water quality of the canal in the survey is generally good with minimal organic pollution.

5. Conclusions & Recommendations

The Union Canal in the Linlithgow area functions as a regionally important wildlife corridor and is ecologically diverse throughout its length. However, its semi urban nature, use as a navigable channel and predation pressure has compromised the ability of the watercourse to provide a stable and well-structured fish population.

The deep sediment and homogeneous aquatic habitat throughout the Linlithgow reach of the canal may be a contributing factor to the comparably low fish density, and although the navigable function of the canal should be of primary importance it is recommended that further work should be undertaken to protect and improve fish stocks.

It is recommended that a feasibility study should be undertaken to assess the viability of providing fish refuges throughout the Linlithgow reach. These refuges could function as spawning and nursery habitat for coarse fish which would not only look to improve the natural development of the stock but could provide cover from avian predation. These measures could then be supplemented by strategic fish stocking once the effectivity of these refuges is ascertained. The juxtaposition of these areas in terms of their effect on boating and angling should be at the forefront of this work.

It is recommended that biosecurity measures should be disseminated amongst all users of the canal network, with notably targeting of anglers who should be encouraged to adopt all measures to prevent transfer of non-native species.

Further information can be obtained at:

http://www.nonnativespecies.org/checkcleandry/