Appendix 10G: Fish Survey Report

Eggborough CCGT

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The lagoon at Eggborough Power Station *© Richard Berridge*

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Appendix 10G: Fish Survey Report
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CONTENTS

1 INTRODUCTION

This report describes the approach and findings of fish surveys undertaken in support of the Ecological Impact Assessment (EcIA) of the Proposed Development. The terms of reference used in this report are consistent with those defined within the main chapters of the Environmental Statement (ES) (Volume I).

The Proposed Development will require the removal of the lagoon within the Proposed Construction Laydown area (also referred to as Water body 1), which is stocked with fish. Works within the River Aire is also anticipated to be required in relation to the Proposed Cooling Water Connections (i.e. works to the existing cooling water abstraction and discharge infrastructure).

1.1 Aim

The aim of the fisheries works is to provide a characterisation of the fish communities present in the lagoon and along the stretch of the River Aire surrounding the existing cooling water abstraction (upstream) and discharge (downstream) points.

1.2 Survey Design

A number of techniques were initially proposed to undertake the fish surveys of both the lagoon and the existing abstraction and discharge points on the River. For the lagoon, the principal technique proposed was point abundance sampling by electric fishing (PASE), surveying both the littoral margin (edge) and the limnetic zone (open water) to provide information on the species present and density estimates for the lake as a whole. Seine nets, hauled from the bank, were also proposed to provide further information on the limnetic zone.

The same two techniques were proposed to survey the relevant stretches of the River Aire. The techniques would both provide information on the species present and density estimates. PASE would provide data for the whole channel, including the littoral/ riparian zone and species within the substrate (*e.g.* bullhead *Cottus gobio*) with seine nets potentially providing more information on open water species.

In addition to the surveys, a brief review of available existing fisheries data and information was to be undertaken.

2 BACKGROUND INFORMATION

2.1 Site Descriptions

2.1.1 The Lagoon

The lagoon, situated in the east of the existing coal-fired power station buildings (within the Proposed Construction Laydown area), is a simple rectangular man-made lined waterbody (Figure 1). The lagoon is considered to be 150 m by 80 m, equating to an area of 1.2 hectares (ha) (derived from Google Earth Pro software). The lagoon is uniformly shallow, with an estimated depth of 1.2 m although there was evidence water levels had been higher in the past.

Figure 1 Satellite image of the lagoon at Eggborough Power Station.

Much of the edge was exposed synthetic liner. However, reed bed, consisting principally of common reed *Phragmites australis* and greater reed-mace *Typha latifolia* was prevalent along the north-western edge with sporadic patches along both the north-eastern and south-western edge (Figure 2). Two patches of white water lily *Nymphaea alba* were present in the south-eastern corner.

The water was ‘crystal clear’ and the submerged macrophyte water milfoil *Myriophyllum* spp was abundant throughout the lagoon.

Figure 2 Areas of the littoral margin created by common reed.

2.1.2 River Aire at Chapel Haddlesey

Cooling Water Abstraction Point

The cooling water abstraction point (Figure 3) for the existing power station is situated between the A19 road bridge and the large weir structure at Chapel Haddlesey (Figures 4 & 5). The stretch is uniformly wide, approximately 50 m across. The main channel depth was generally between 2.5 and 3 m, although some areas were more than 4 m in deep. No areas were wade-able. Water clarity was good, with an estimated 1.2 m Secchi depth.

Submerged and emergent macrophytes were sporadic along the edge of the river with common reed, water starworts *Callitriche* spp., hornwort *Ceratophyllum demersum* and Canadian waterweed *Elodea canadensis* observed. On the northern bank, a number of willow *Salix* spp. trees, particularly in the residential sections, were overhanging the river. Both banks were steep sided, with Himalayan balsam *Impatiens glandulifera* and common nettles *Urtica dioica* prevalent.

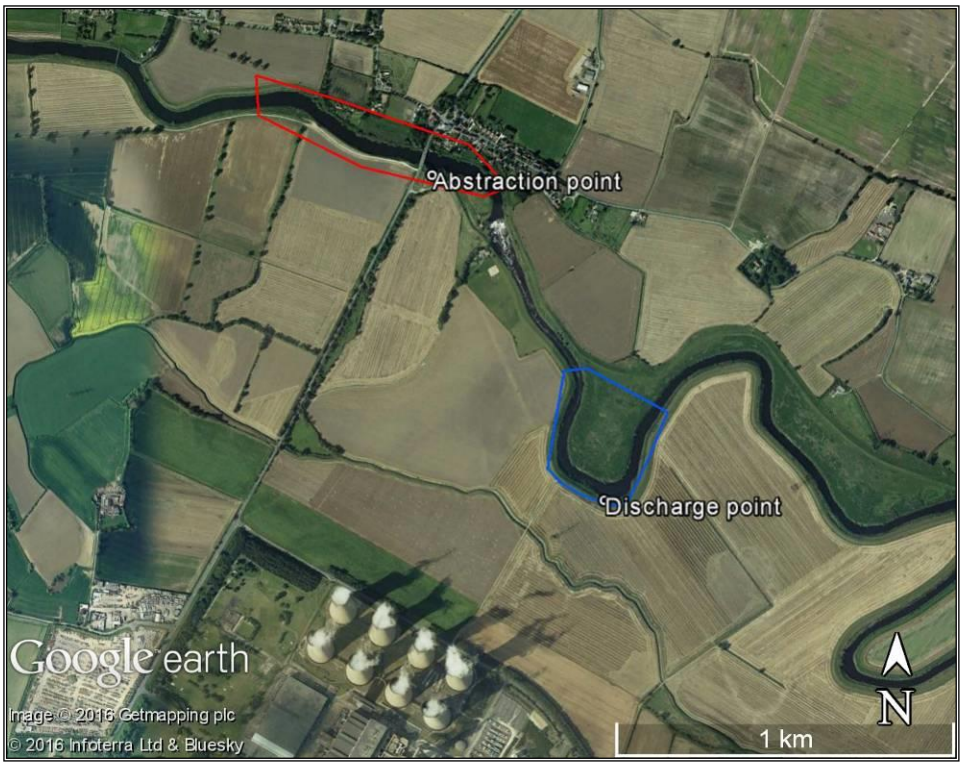

Figure 3 Satellite image of the River Aire, detailing the up and downstream sections associated with the abstraction and discharge points.

Figure 4 Typical view of the upstream section including the abstraction point on the River Aire at Chapel Haddlesey.

Figure 5 The weir structure on the River Aire separating the up and downstream sections.

The fishing rights for this section of the River Aire are controlled by the Leeds & District Amalgamated Society of Anglers (LDASA). A number of pegs are present on both sides of the bank.

At the time of surveying, a hydroelectric facility was under construction, which will also modify the existing weir to incorporate fish passes (Fryer & Coe 2013). Water will be abstracted for the Archimedian Screw Hydro Turbines plant from downstream of the existing coal-fired power station abstraction point and discharging the water downstream of the weir.

Cooling Water Discharge Point

Downstream of the weir, the River Aire is tidal. During the survey, it was estimated that the river level dropped by 0.8 to 1.0 m over a two and a half hour period. In general, the channel was wider and the banks steeper (Figure 6). The area appeared to be more managed than at the abstraction point, with few trees present and the vegetation along the flood defence banks appearing to be cut. Large rocks appeared to have been used to strengthen the base of the river banks. Some fishing pegs were present, but control over the fishing rights was unclear.

Figure 6 Typical view of the downstream section viewed from the discharge point.

2.2 Summary of Available Fisheries Information

2.2.1 The Lagoon

Historically, the man-made lagoon was intensively fished with matches regularly undertaken (Eggborough Power Station staff *pers*. *comm*.). However, no fisheries information on the lagoon was available for review. Anecdotally, large pike were thought to be present.

2.2.2 The River Aire at Chapel Haddlesley

Environment Agency fisheries data for the River Aire[1], accessible under 'Open Government Licence (https://data.gov.uk/dataset/freshwater-fish-counts-for-all-species-all-areas-and-all-years), was available for surveys conducted at Chapel Haddlesey between 1998 and 2015. Nine fry surveys, which use seine nets, were conducted between 2000 and 2015. During these fry surveys, 14 fish species were caught in total. Electric fishing surveys conducted upstream of the A19, between 1998 and 2010, recorded ten species of fish, with three not

[1] © Environment Agency copyright and/or database right 2016

recorded in the seine nets. Finally, a gill net survey conducted in 2003 resulted in the capture of just three fish species (Table 1).

Table 1 Fish species present in the Environment Agency surveys at Chapel Haddlesey between 1998 and 2015 by seine net, electric fishing and gill net.

	Seine net	Electric fishing	Gill net
European eel		✓	
Silver bream	✓	✓	✓
Common bream	✓	✓	
Common bleak	✓	✓	
Common barbel	✓		
Common gudgeon	✓	✓	✓
Chub	✓	✓	
Dace	✓		
Minnow	✓		
Roach	✓		✓
Roach x bream hybrid		✓	
Rudd		✓	
Stone loach	✓		
Pike	✓		
Three-spined stickleback	✓	✓	
Ten-spined stickleback	✓		
Perch	✓	✓	

It is of note that of the 17 species caught during this period, only seven have been present in surveys conducted from 2010 onwards. Fish that have not been caught recently include European eel *Anguilla anguilla*, common bleak *Alburnus alburnu*s, common barbel *Barbus barbus* and dace *Leuciscus leuciscus*. Silver bream *Abramis bjoerkna* were also only present in the 2010 survey have not been captured subsequently.

In the surveys conducted from 2010 onwards, various species have been numerically dominant. Roach *Rutilus rutilus* comprised of 80% of the total catch in the electric fishing survey of 2010, and 85% and 65% of fry surveys of 2013 and 2015 respectively. Three-spined stickleback *Gasterosteus aculeatus* were the most numerous fish in the fry surveys during 2010 and 2012, with gudgeon *Gobio gobio* dominant in 2014.

The fisheries assessment for the hydropower scheme, currently under construction, detailed a fish community based on Environment Agency data from electric fishing surveys conducted at Kirkstall, approximately 30 km upstream of Chapel Haddlesey, between 2004 and 2010 (Fryer & Coe 2013). In total 11 species were recorded, three of which, brown trout *Salmo trutta*, grayling *Thymallus thymallus* and bullhead, were not present in the Environment

Agency surveys at Chapel Haddlesey. The report also noted that twait shad *Alosa fallax*, allis shad *Alosa alosa*, smelt *Osmerus eperlanus*, common barbel *Barbus barbus*, sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* were believed to be present in the tidal stretch of the River Aire downstream of the weir.

Further information published in a review of the River Aire fish populations by Sunderland (2013), also suggests that Atlantic salmon *Salmo salar* have recently begun to return to the river given improvements in water quality and access. In October 2007, the first sightings in recent times of salmon trying to ascend Knottingley Weir (the next weir upstream of Chapel Haddlesey) were made and the Environment Agency caught 10 salmon, two sea trout and a large brown trout below Chapel Haddlesey soon after (Sunderland 2013). Further sightings of salmon attempting to ascend Knottingley Weir have also been made annually between 2009 and 2012 (Sunderland 2013). The Humber River Basin District River Basin Management Plan 2009 (updated in 2015), in part aims to tackle barriers to fish migration, with the goal of returning self-sustaining spawning populations of migratory fish to all the Humber Region rivers. This primarily involves the elimination of barriers (through removal or introduction of passes) and improvement in water quality, though habitat creation may also be important.

LDASA who own the fishing rights for stretch of the River Aire upstream of the A19 road bridge at Chapel Haddlesey were contacted requesting information on their catches, including a recent match, but at the time of writing they had not responded.

3 METHODS

Fisheries surveys were conducted by an ECON fieldwork team between 1st and 3rd November 2016. The methods employed at the lagoon and on the River Aire are detailed below.

3.1 The Lagoon

Two survey techniques were employed at the lagoon, PASE and seine netting (see 3.1.1 and 3.1.2 below). In addition, free electric fishing of the key habitats and three sides of the lagoon were undertaken to provide further information on the fish community.

3.1.1 PASE

Surveys were conducted from a 3 m fibreglass dinghy manoeuvred by push rowing. The electric fishing equipment used is detailed in Table 2. The anode has a 2.5 m operative length with a relatively large (380 mm ring, which aims to reduce the danger zone close to the anode and thus potential fish mortality (Novotny 1990).

Table 2 Details of the electric fishing equipment used in the PASE survey of the lagoon at the existing power station.

Unit	Input amps (A)	Frequency (Hz)	Output volts (V)
Electracatch WFC3i	<1	50	c. 25

The equipment induces effective galvanotaxis of fish towards the anode within a sphere of influence. Fish may react slightly differently to the anode, depending on size and species, but will generally move toward the anode, and after becoming incapacitated may be caught in a long-handled net. The sphere of influence, and thus the sampled area, was determined from the distance from the anode at which the voltage gradient decreased to 0.12 volts (V), the minimum effective voltage at which inhibited swimming occurs (Copp & Peñáz 1988). This was measured as 350 mm from the ring, equating to a point sample area of 0.92 m^2. This allowed quantitative estimates of abundance and biomass of individual fish species and total fish to be calculated. All estimates were expressed as individuals (ind.) and biomass per unit area (*i.e.* ind. m^{-2} and g m^{-2} respectively).

At each point, the anode was rapidly immersed and the net swept through the point, thereby collecting all stunned fish even where none are seen. All fish captured were identified to species level, fork length measured (to the nearest mm) and any particular characteristics of individual fish were noted including any ailments or obvious parasites. An estimate of weight (biomass) in grams (g) was calculated from length-weight regression relationships for each

species compiled and held by ECON. The exception to this was the individual weighing of large specimens using a spring balance and weigh sling. The location of each point sampled was logged using a global position system (GPS) for later geographical analysis.

At each littoral margin point, the width of the margin considered available to fish was estimated and emergent and/or overhanging vegetation within a 'visualised transect' was noted. All vegetation was identified to species level where possible. At limnetic points, all submerged macrophytes (including macro-algae) were identified where possible and an estimation of their cover (%) was made. The numbers of points sampled in the lagoon are shown in Table 3.

Table 3 Area (m^2) and number of points sampled in the limnetic and littoral zones of the lagoon at the existing coal-fired power station

Habitat	Area (m^2)	Number of points
Limnetic	12,066	68
Littoral	1,034	63

Separate fish density estimates were calculated for the limnetic zone and the littoral margin by calculating a mean from the density estimates for individual sample points (number or biomass/ sampled area). These separate densities were combined to provide an estimate for the whole lagoon by determining the relative size of each zone (Table 3) and adjusting the figures accordingly. The overall estimate, by nature of the calculation, does not have a measure of variance (standard error [SE]). However, an indication of variance and thus confidence in the estimate is provided by the variance for each sampled zone. The advantage of theoretically providing a better overall estimate has been deemed to outweigh the disadvantage of the lack of an overall measure of error.

3.1.2 Seine Net

Two hauls were conducted from the north-eastern bank of the lagoon. A 60 m long and 5 m deep seine net was used, with a 5 mm mesh size in the central bag area. The net was set from the same 3 m fibreglass dinghy. The track from a hand held GPS unit allowed the estimation of the area enclosed by each haul as a measure of effort.

After setting, the seine net was hauled by the float line by all personnel. When the net was within 3 m of the bank, the lead line was rapidly hauled by two personnel, whilst the remaining two held the float line to prevent it from submerging, creating an enclosed area. Fish enclosed in the net were removed using long handled nets and submerged macrophytes

contained within the net were searched for further fish. All fish captured were processed as per the PASE survey (see 3.1.1 above).

The abundance (ind. m^{-2}) and biomass (g m^{-2}) of each species from each haul was calculated by dividing the total number of individuals or biomass by the area of the haul.

Due to the abundance of submerged macrophytes and the shallow nature of the lagoon, the seine nets did not function efficiently. Thus, there was little confidence in this technique and an overall density for the lagoon was not calculated using this method.

3.2 River Aire

Due to the lack of suitable banks from which to haul seine nets safely, this survey technique could not be employed on the sections of the River Aire to be surveyed. In addition, the water depth reduced the efficiency of the PASE technique (see 3.2.1). Further to the PASE, a continuous electric fishing run along sections of the accessible littoral/ riparian zone, was used to provide a catch per unit effort (CPUE).

3.2.1 PASE

The equipment and principals of the technique is described in Section 3.1.1 above. The survey was conducted systematically, sampling points along the river in an upstream direction. Points were sampled approximately 10 m apart, with one point in every ten sampled along the river's edge. The numbers of points sampled in each of the sections surveyed are presented in Table 4.

Table 4 Number of points and the total length for CPUE sampled at the existing cooling water abstraction and discharge sites on the River Aire.

Site	Number of points	Length sampled for CPUE
Abstraction (US)	50	320
Discharge (DS)	50	320

3.2.2 CPUE

Free electric fishing, exploring all available wetted habitats along a stretch of the riverbank, was undertaken using the same equipment and all fish captured were processed as detailed above. Both banks were sampled, with the southern bank sampled from the downstream end of the site working up to either the abstraction point/ discharge point and along the opposite bank working to the upstream end of each site.

Using GPS waypoints, the length of riverbank sampled (Table 4) was derived to enable estimates of CPUE of fish per 100 m sampled (ind. 100 m^{-1}).

4 RESULTS

4.1 The Lagoon

Five species were captured in the PASE survey of the lagoon. In order of abundance these were rudd *Scardinius erythrophthalmus* (60 ind.), tench *Tinca tinca* (17 ind.), perch *Perca fluviatilis* (6 ind.), crucian carp *Carassius carassius* (9 ind.) and a single common carp *Cyprinus carpio*. Overall density estimates were calculated to be 0.3 ind. m^{-2} and 59.6 g m^{-2} (Table 5).

Rudd dominated the fish community by number (Figure 7). A number of age classes of rudd were captured by all techniques (Table 6), with young-of-the-year (YOY) fish ranging from 28 to 38 mm and 1+ fish (hatched in 2015) between 43 and 63 mm. The fish ranging from 70 to 117 mm are likely to represent 2+ (2014) and 3+ (2013) fish. A fish at 141 mm is likely a 4+ fish and the 220 mm specimen a much older fish (Figure 8). All the YOY rudd captured were present in the limnetic zone amongst the submerged macrophytes (see below).

Table 5 Mean (±*1SE*) abundance and biomass of all fish species captured in the PASE survey of the lagoon at the existing power station

Species		Limnetic zone		Littoral margin		overall	
		ind. m^{-2}	g m^{-2}	ind. m^{-2}	g m^{-2}	ind. m^{-2}	g m^{-2}
Crucian carp	Mean	0.02	0.98	0.14	3.92	0.03	1.22
	SE	*0.02*	*0.98*	*0.06*	*1.93*		
Common carp	Mean	0.02	61.91	0.00	0.00	0.01	57.03
	SE	*0.02*	*61.91*	*0.00*	*0.00*		
Rudd	Mean	0.13	0.07	0.90	6.38	0.19	0.57
	SE	*0.06*	*0.03*	*0.45*	*3.98*		
Tench	Mean	0.00	0.00	0.29	5.23	0.02	0.41
	SE	*0.00*	*0.00*	*0.07*	*1.64*		
Perch	Mean	0.02	1.23	0.09	1.34	0.02	1.24
	SE	*0.02*	*1.23*	*0.04*	*0.71*		
Total	Mean	0.18	63.21	1.41	16.87	0.27	59.56
	SE	*0.06*	*61.90*	*0.47*	*5.17*		

Common carp, including ornamental koi carp varieties, dominated the community by biomass (Figure 7) due to the capture of a single large specimen (Figure 9) with a biomass of 4.2 kilogrammes (kg). Another carp was captured in the additional electric fishing (Table 6) with the 104 mm specimen potentially a 1+ fish.

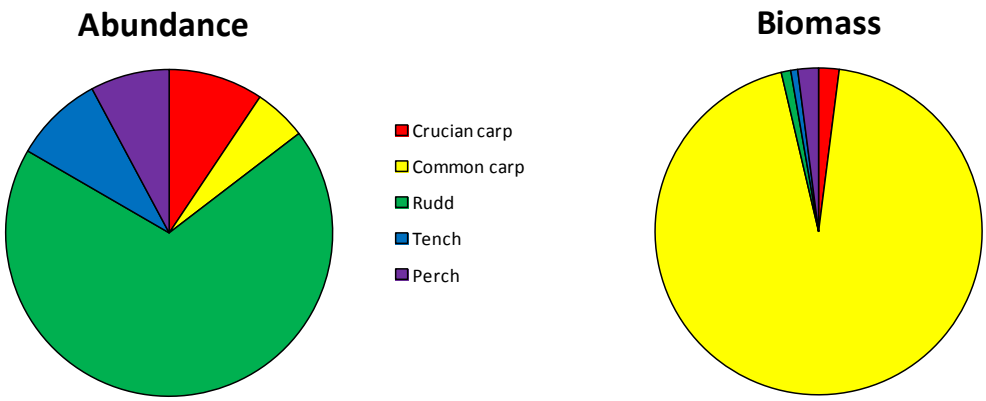

Figure 7 Species composition (%) by number and biomass as derived from the PASE survey of the lagoon at the existing power station

The crucian carp captured (Table 6) are likely to consist of a number of age classes, with the smallest potentially YOY specimens with excellent growth rates. The perch appeared to exhibit excellent growth rates, possibly due to early piscivory, with YOY fish exceeding 100 mm in fork length. Two large specimens weighing 1.1 kg and 1.5 kg were captured in the free electric fishing exercise. Various of age classes of tench were also encountered, although only a single YOY fish (39 mm) was captured. The majority of the tench caught (58 to 121 mm) could represent three further age classes (e.g. 1+ to 3+).

Table 6 Range in fork length (mm) of all fish captured by all fisheries techniques employed at the lagoon at the existing coal-fired power station

Species	Fork lengths (mm)
Crucian carp	58 – 136
Common carp	104 – 498 (4.21 kg)
Rudd	28 – 220
Tench	39 – 203
Perch	95 – 425 (1.49 kg)

Figure 8 A good-sized rudd caught within a reed bed.

Figure 9 A large common carp caught in open water amongst macrophytes.

Submerged macrophytes were recorded in 93% of the open water points. Only a single species, water milfoil, was identified, though macro-algae, probably *Hydrodictyon* spp., was also present. The mean cover of submerged macrophytes at these points was calculated to be 52%, ranging from 5% to 100%. Of the littoral points, 53% recorded habitat created by emergent or floating macrophytes, with the average amount of habitat available to fish estimated to be 2.2 m in width. Three species of key emergent 'reed' were present, common reed, greater reed-mace and common club-rush *Schoenoplectus lacustris*. A patch of sedge *Carex* spp. was also present, along with white water lily, rushes *Juncus* spp. and yellow flag iris *Iris pseudacorus*.

4.2 River Aire

4.2.1 Cooling Water Abstraction Point

Seven species were captured using the two techniques employed at the area surrounding the existing cooling water abstraction point. In taxonomic order these were: gudgeon, roach, tench, pike *Esox lucius*, three-spined stickleback, bullhead and perch. Just a single species, perch, was captured in the PASE survey, resulting in density estimates of 0.02 ind.m^{-2} and 1.8 g m^{-2} (Table 7). Based on the continuous electric fishing, perch had a CPUE of 0.9 ind. 100 m^{-1} (Table 7).

Table 7 Mean (±*1SE*) abundance and biomass of all fish species captured in the electric fishing surveys of the upstream section of the River Aire.

Species		PASE		CPUE	
		ind. m^{-2}	g m^{-2}	ind. 100 m^{-1}	g 100 m^{-1}
Gudgeon	Mean			0.31	0.19
	SE				
Roach	Mean			0.31	0.97
	SE				
Tench	Mean			0.31	5.60
	SE				
Pike	Mean			0.31	154.11
	SE				
Three-spined stickleback	Mean			0.31	0.22
	SE				
Bullhead	Mean			0.31	1.50
	SE				
Perch	Mean	0.02	1.85	0.94	43.72
	SE	*0.02*	*1.85*		
Total	Mean	0.02	1.85	2.81	206.31
	SE	*0.02*	*1.85*		

The fork lengths of all fish captured are presented in Table 8. The perch captured ranged from 122 to 182 mm, probably representing two age classes (2+ to 4+ fish) (Table 8).

Table 8 Range in fork length (mm) of all fish captured by all fisheries techniques employed at the upstream section of the River Aire.

Species	Fork lengths (mm)
Gudgeon	35
Roach	60
Tench	101
Pike	400
Three-spined stickleback	35
Bullhead	60
Perch	122 – 182

4.2.2 Cooling Water Discharge Point

Seven species were also captured by the two techniques near to the existing cooling water discharge point. These were gudgeon, dace, roach, pike, three-spined stickleback, perch and Atlantic flounder *Platichthys flesus* (Figure 10). Of these, only roach and pike were caught during the PASE survey, resulting in total fish density estimates of 0.1 ind. m^{-2} and 61.3 g m^{-2} (Table 9). Roach, principally utilising the rocks as habitat, were the most abundant fish in the continuous electric fishing exercise, equating to 13.4 ind. $100m^{-1}$. Perch were encountered along the river's edge at rate of 1.9 ind. 100 m^{-1} and flounder at 0.9 ind. 100 m^{-1} (Table 9).

Two age classes of roach were captured, with YOY and 1+ fish incorporated in the fish from 35 to 84 mm in fork length (Table 10).

Figure 10 A flounder caught downstream of the weir.

Table 9 Mean (±*1SE*) abundance and biomass of all fish species captured in the electric fishing surveys of the downstream section of the River Aire.

Species		PASE		CPUE	
		ind. m^{-2}	g m^{-2}	ind. 100 m^{-1}	g 100 m^{-1}
Gudgeon	Mean			0.31	0.14
	SE				
Dace	Mean			1.25	5.58
	SE				
Roach	Mean	0.04	0.03	13.44	39.53
	SE	*0.04*	*0.03*		
Pike	Mean	0.02	61.24	0.31	8.88
	SE	*0.02*	*61.24*		
Three-spined stickleback	Mean			1.56	2.24
	SE				
Perch	Mean			1.88	39.53
	SE				
Atlantic flounder	Mean			0.94	12.44
	SE				
Total	Mean	0.07	61.28	19.69	108.35
	SE	*0.05*	*61.24*		

Table 10 Range in fork length (mm) of all fish captured by all fisheries techniques employed at the downstream section of the River Aire.

Species	Fork lengths (mm)
Gudgeon	32
Dace	41 – 107
Roach	35 – 84
Pike	150 – 728
Three-spined stickleback	35 – 47
Perch	70 – 143
Atlantic flounder	96 – 125

5 DISCUSSION

5.1 Fish Community

5.1.1 The Lagoon

The lagoon within the existing coal-fired power station supports a simple fish community of four cyprinid species, rudd, tench, crucian carp and common carp and a single piscivorous species in perch (Table 5; Figure 7). Due to the nature and history of the lagoon, this community is likely a result of introductions by site staff. Equally, when fishing ceased at the lagoon, fish may have been removed, particularly those of high recreational angling value. Other fish species could exist in very low numbers (*i.e.* anecdotally pike were the only species reported to be present), but based on the condition of the lagoon (*i.e.* clear water - macrophyte dominated) it would seem unlikely that it has supported a large, high-density fish community in recent years.

The overall abundance estimate was relatively low at 0.3 ind. m^{-2}, equivalent to around 3,500 fish in total. There is, however, potential for greater numbers of fish to be supported in the future within the lagoon, as recruitment by the species present could be better. Whilst there was evidence of recruitment by perch and rudd, only in the case of perch (assuming good growth rates) were YOY the dominant age class (see below). There was also evidence of good recruitment in previous years by the cyprinid species and the lagoon could historically have supported greater populations. Thus, there is potential for greater recruitment whilst the lagoon exists.

The biomass estimate was considerably greater at 59.5 g m^{-2} (Table 5), or 596 kg ha^{-1}. As a means of comparison, Natural England have guidelines that Site of Special Scientific Interest (SSSI) lakes should not exceed 200 kg ha-1 and stillwater biomass levels for a mature lowland estate lake of 350 kg ha^{-1} are promoted by the Environment Agency (http://northerntrout.co.uk/docs/stocking__eng_172017.pdf). However, this biomass was a result of the capture of a single large common carp in the open water and the derived estimated common carp biomass is likely to be an overestimation. To achieve the estimated 570 kg ha^{-1}, the number of common carp of comparable size of the adult captured (4 kg) would have to exceed 150 fish, whereas fewer than 50 are more likely to be present (see below). Whilst the carp biomass can be considered an overestimate, as no adult perch were captured in the PASE survey, or adult tench by any technique, biomass for both species are likely to be conservative. Using the experience of all the works undertaken with observations, the lagoon could support an overall fish biomass of <150 kg ha^{-1}.

The surveys revealed that rudd dominated the fish community numerically, with a strong and healthy population. Using all the data and information from the lagoon it appears that the rudd population has been dominant for a number of years. Comparable numbers of YOY and 1+ fish were captured (this indicates that greater numbers of YOY fish were present in 2015), whereas the rudd of 70 to 117 mm, considered to be 2 and 3+ fish represented 68% of the total catch. This suggests the species has consistently recruited with good annual survival rates in recent years and that the abundance could have been higher in 2013/2014.

That there were fewer numbers of YOY rudd present in the lagoon at the time of surveying may be linked to the principal predator, perch. The apparent excellent growth rates of the YOY perch, reaching 110 mm indicates early piscivory. Borcherding *et al*. (2000) showed that YOY perch can consume YOY bream fry up 19 mm in length where these are available, thus promoting fast growth in perch fry. With further age classes captured in the fisheries works, including two very large specimens (Figure 11), the population can be considered stable. Based on the evidence of reduced recruitment in 2016 by the other species within the fish community, perch recruitment may have been more successful this year.

In common with rudd, tench are also associated with clear water conditions and submerged macrophytes, both present in the lagoon. A number of different age classes of tench were present in the overall catch, revealing previous recruitment success and good levels of annual survival rates. However, similarly to rudd, recruitment appeared limited in 2016, which could be linked to perch population. However, with the crucian carp population apparently failing to recruit to previous levels, general conditions in the lagoon (*e.g.* water temperature or water levels) may have restricted recruitment (the spawning season for both rudd and perch (April to June) are slightly earlier than crucian carp (May to June) and tench (May to July) – Maitland 2000).

Figure 11 A very large perch caught amongst the lily beds.

In contrast with the other species, there was little evidence of previous successful recruitment by common carp, with just a single juvenile fish recorded. Two large adult common carp were captured, although both had potential issues with their swim bladders. Whilst the fish showed no external symptoms and the gills were healthy, both fish swam on their sides (Figure 12) and thus were easy to capture. Other healthy common carp were observed, including a much larger specimen, which did respond typically to the presence of the surveyors. Furthermore, three ornamental carp were encountered regularly, but did not respond to the presence of the surveyors, either in the boat or from the water's edge, allowing photographs to be taken from close range (Figure 13). Most of these fish were observed, and remained, in the northern/ north-eastern sections of the lake, suggesting that the number of adults in the lagoon is anticipated to be fewer than 50 individuals (see above).The number of juvenile fish may be greater, but most key habitats were explored and only one smaller fish was encountered. Thus, it is unlikely the population is self-sustaining and will likely die out given sufficient time.

Figure 12 A common carp swimming on its side.

Figure 13 Group of three ornamental carp regularly encountered during surveys.

5.1.2 River Aire

Cooling Water Abstraction Point

The fisheries work revealed that the fish community of the upstream section of the River Aire, associated with the existing cooling water abstraction point, is comprised of at least seven species, perch, roach, gudgeon, pike, tench, three-spined stickleback and bullhead. Due to the nature of the environment, the fish community of the River Aire will not be limited to the species captured in the current fish survey, regardless of the limitations of the fisheries techniques employed (see Section 5.2.2 below). In the upstream section above the weir, with the exception of chub and minnow, all species captured in the Environment Agency surveys

of the Aire at Chapel Haddlesey since 2013 were captured in the current electric fishing surveys. It is also of note that neither tench nor bullhead has been captured in this stretch in the Environment Agency surveys.

The historic data indicates that species richness has declined in the Aire at Chapel Haddlesey, with species such as bleak, silver bream and barbel absent from recent surveys. Whether these species have been lost from the wider River Aire is unclear from the scope of these works. However, the planned fish pass as part of the improvements to the weir downstream of the abstraction point, the lowest barrier on the Aire, should allow migratory species to access to this stretch of the river. Species such as sea trout *Salmo trutta*, Atlantic salmon, river and sea lamprey could be encountered during their migration, however in the case of lamprey, there isn't the required habitat, particularly for the ammocoetes (juvenile fish), which require areas of fine sediment with a high organic content. An eel pass (in addition to the fish pass) is also planned which could result in this catadromous (migrating from freshwater to spawn at sea) species utilising the habitat available adjacent to the abstraction point.

The habitat within the stretch of river is largely restricted to overhanging vegetation and some in-channel macrophytes and this is largely reflected in the density estimate. Although there was a lack of confidence in the efficiency of the PASE survey, the density estimate of just 0.02 ind. m^{-2} was poor. Even sampling the littoral zone which contained suitable habitat for fish only equated to a CPUE of 3 ind. 100 m^{-1} (Table 7). The generally low density is also supported by the Environment Agency data for Chapel Haddlesey, with numbers of fish, similar to the species richness, reducing over time. For example, 989 fish were captured in the seine nets in 2000, compared to just 21 fish in 2012 and 60 fish in 2015.

Cooling Water Discharge Point

Again seven species were captured in the downstream section of the River Aire, associated with the existing cooling water discharge point. Perch, roach, gudgeon and pike were also present in this section with dace and Atlantic flounder also captured. The fish community was broadly similar to that upstream of the weir, with dace previously captured in Environment Agency surveys at Chapel Haddlesey. The habitat present between the two sites was generally the same, hence the similar fish communities and densities. However, available habitat for fish from riparian vegetation will vary with the tidal water level. An apparent difference between the two sites was the rock 'footings' of the river bank; however, this observation was due to the falling water levels, and the rocks may have been present but unobserved in the upstream section. This downstream site is tidal and there are no barriers

to the confluence at the Ouse at Goole and ultimately the Humber Estuary, reflected in the presence of typically marine flounder.

In addition to the number of flounder encountered, the exposure of the rocks along the riverbank resulted in the capture of a greater number of fish than the upstream site. Roach, both YOY and 1+fish, and three-spined stickleback utilised the interstitial areas created by the rocks as refuges. This was reflected in a CPUE of 13 ind. $100m^{-1}$ for the former species (Table 9). Whilst the CPUE for all fish species was considerably greater for the downstream section (20 ind. $100m^{-1}$), this was not necessarily reflected in the density derived from PASE (0.07 ind. m^{-2} – Table 9).

5.2 Survey Limitations

5.2.1 The Lagoon

Seine nets were included in the survey design for the lagoon in order to increase the sampling effort in the limnetic zone and increase the chances of the capture of 'rarer' large specimen fish. However, the sampling efficiency of the technique was poor, due to the shallow nature of the lagoon and the very good cover of the submerged macrophyte, water milfoil, combined with the large depth (5 m) of the seine net employed. Nonetheless, the aforementioned characteristics of the lagoon meant that PASE was arguably the best technique to sample the limnetic zone quantitatively (see Perrow *et al*. 2015). Equally, the technique did result in the capture of a large adult common carp.

The free electric fishing of the key habitats and most of the littoral margin did not add any further species, though some larger specimens were encountered, supporting the suitability of PASE as the primary technique and thus the findings of the survey.

5.2.2 River Aire

The depth of the water at both up and downstream sites of the River Aire (in excess of 2 m) reduced the efficiency of the PASE surveys of the sites. The substrate, and anything below the operating length of the 2 m anode, was not effectively sampled, although shoaling species such as roach and minnow *Phoxinus phoxinus* could have been sampled if encountered. All the fish captured in the PASE surveys were present in the littoral points (typical sampled one in ten points), where most of the habitat available to fish was present. This confirms that whilst not quantitative, continuous electric fishing of the margin, exploring all available habitat, was a suitable technique for the River Aire, in providing a qualitative reflection of the fish community, particularly as it was the lower reaches.

Seine nets sampling were part of the original design for the survey and would be the most efficient means of surveying the main channel. With no suitable bankside locations, seine nets would have to be set and hauled from floating pontoons by a larger team of surveyors.

5.3 Recommendations for Potential Future Fisheries Works

Based on the fisheries works undertaken by ECON at the lagoon, electric fishing, supported by fyke nets, would be the most appropriate approach for a fish removal. Repeated continuous electric fishing of the key habitats should be employed (a brief exercise of the reed beds in the north east section quickly resulted in the capture of over 100 fish). Sections of the limnetic zone could be created using lengths of stop nets, which again could be repeatedly fished. Fyke nets would capture fish leaving the littoral habitats to forage in the open water at night, and also the larger specimens, common carp, perch and tench already utilising the habitat. Seine nets could be employed, but smaller nets, particularly in regard to depth, would be required and the timing would be best limited to winter.

Prior to any fish removal, a number of aspects regarding both the fish and the management of the project require consideration. In certain circumstances, fish can be transferred into an isolated lake or pond without a Section 30 health check (although permission from the Environment Agency will still be required). As an initial step, a suitable local receptor site could be sourced, or a new pond could even be created as part of the Proposed Development. The latter would potentially mean the fish could again be available to staff for recreational angling. If a site (or sites), that would require a health check is selected, then a sample of each fish species (a minimum of 30 fish) will be required to be assessed by an authorised contractor. Once approved, the fish can then be moved. However, the required sample size would be almost as many large carp (few smaller carp were likely to be present) as there are believed to be present in the lagoon and thus few would remain for transfer. Therefore, if a site that does not require a health check cannot be identified, a better option would be to find a reputable fisheries contractor to collect the fish.

In regards to the River Aire, given the recent observations of salmonids moving above the weir at Chapel Haddlesey, and creation of the new fish pass around the weir, consideration should be given to salmonids. Thus, ideally the timing of any works on the abstraction and discharge points should focus on periods outside of the main salmonid migratory season (October to December) to reduce any potential disturbance.

6 SUMMARY AND CONCLUSIONS

- Three fisheries techniques were used to survey the fish community in the lagoon within the existing power station: PASE, seine nets and free electric fishing.
- Five species were captured in the survey of the lagoon. These were rudd, tench, perch, crucian carp and common carp. Overall density and biomass estimates for the lagoon were 0.3 ind. m^{-2} and 59.6 g m^{-2} respectively. Rudd dominated the fish community by number and common carp by biomass.
- A health check for the fish community and assessment of the nature of the crucian carp is recommended if removals are required. Electric fishing methods, combined with the use of fyke nets, would provide a suitable means for any potential removal exercise.
- PASE and continuous electric fishing, combined with historic data, provided information on the fish community of the River Aire at the existing cooling water abstraction and discharge points.
- Roach, perch, gudgeon, pike, three-spined stickleback were present at both the upstream and downstream sites, with tench and bullhead also captured at the upstream site and dace and flounder at the downstream site. Fish densities were low at both sites at 0.02 and 0.07 ind. m^{-2} at the up and downstream sites respectively.

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