

Fish Populations in the River Usk: Results from Electrofishing in Riffles

Prepared by James Hawkins and Carys Cronin. Statistical analyses by Sam Orpin, Electrofishing Surveys led by Jamie Carruth

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Introduction

The River Usk (*Afon Wysg*) is one of the largest and most ecologically significant rivers in Wales, originating on the northern slopes of Mynydd Du (the Black Mountain) in the Bannau Brycheiniog and flowing approximately 137 kilometres before entering the Severn Estuary at Newport (Figure 1). The Usk and its tributaries drain a catchment of around 2,400 km², home to a range of habitats that support a variety of aquatic and riparian species. Recognising its exceptional ecological value, the river was designated as a Site of Special Scientific Interest (SSSI) in 1995 and later as a Special Area of Conservation (SAC) in 2005 under the EU Habitats Directive.

The SAC designation reflects the importance of the Usk for its fish populations, particularly Atlantic salmon (*Salmo salar*), as well as bullhead (*Cottus gobio*) and several lamprey species (*Petromyzon marinus*, *Lampetra fluviatilis*, *L. planeri*). The river's upper reaches provide key spawning grounds for migratory salmonids, while its middle and lower sections support a range of resident species, including brown trout (*Salmo trutta fario*), minnow (*Phoxinus phoxinus*), and stone loach (*Barbatula barbatula*). This diversity, along with the presence of rare migratory species such as twaite shad (*Alosa fallax*), underscores the Usk's status as one of the most biologically important river systems in the UK. Notes on some of these species are contained in the boxes on the right of this text.

Despite its high significance for conservation, the ecological condition of the River Usk has deteriorated in recent decades. Natural Resources Wales (2020) now classifies all 9 of the Usk's designated SAC features as "Unfavourable – Declining". Populations of key species in the River Usk have declined markedly over recent decades. Atlantic salmon and sea trout have shown substantial reductions since the early 2000s (Mawle, 2020; Dadswell

Atlantic Salmon (*Salmo salar*)

An anadromous species, Atlantic salmon spawn in gravel-bottomed riffles of clean, fast-flowing rivers. After hatching, juveniles remain in freshwater for 1–3 years before migrating to sea as smolts. Adults return to their natal rivers to spawn.

Brown Trout (*Salmo trutta*)

A resident salmonid, the brown trout inhabits cool, oxygen-rich streams with stony or gravel beds. It feeds on insect larvae, small fish and terrestrial invertebrates. Spawning occurs Jan–Mar in shallow riffles. Eggs are laid in redds and covered with gravel.

Minnow (*Phoxinus phoxinus*)

A widespread, shoaling fish found in both upland and lowland freshwater habitats, including fast streams and nutrient-poor lakes. It feeds on algae, detritus, molluscs, insects, and crustaceans.

et al., 2021), despite the river’s historic reputation as “a river famous for its salmon” and having had the highest estimated egg deposition of any British river south of Cumbria in 1999 (JNCC, 2015). Data indicate that brown trout numbers have fallen by approximately two-thirds in key areas, and sea trout stocks are now considered “At risk.” Other important species have experienced similar declines: European eel abundance has dropped sharply in line with trends across Western Europe, and the rare freshwater pearl mussel may now be locally extinct. At the same time, the limited frequency and scope of statutory monitoring means that much of the current understanding of fish population trends in the Usk remains incomplete (Mawle, 2021).

The Wye and Usk Foundation (WUF) has conducted annual electrofishing surveys across the Usk catchment since 2013. The primary purpose of these surveys was to build up information on trout and salmon populations and this determined decisions on the type of survey site to be sampled and the electrofishing procedures to be adopted.

The sites sampled were all ‘riffles’. These are defined as a shallow, fast-flowing section of a river where water passes over coarse substrate—typically gravel, cobbles, or small boulders—creating turbulent, well-oxygenated flow.

The data presented here come from the years 2016 to 2024 during which the number of sites surveyed has ranged from 60 to 143. They provide useful information on distribution and abundance, not just of trout and salmon but also of the other fish species that were encountered. This report presents the first systematic analysis of these electrofishing results, evaluating temporal and spatial trends. It is hoped that the findings will inform future management and conservation strategies for maintaining and restoring the river’s ecological integrity.

Stone Loach (*Noemacheilus barbatulus*)

A small benthic species adapted to fast-flowing, well-oxygenated streams and rivers with sandy or gravelly beds. Spawns between April and August, with females depositing thousands of eggs among stones and aquatic plants.

It is a nocturnal feeder on invertebrates, including mayfly larvae and freshwater shrimp.

European Eel (*Anguilla anguilla*)

A critically endangered catadromous species with a complex, four-stage life cycle.

Born in the Sargasso Sea, larvae drift on ocean currents to Europe and migrate into rivers like the Usk, where they may remain for over 20 years. As adults, they transform into silver eels and return to sea to spawn and die.

European Bullhead (*Cottus gobio*)

A small, bottom-dwelling fish found in cold, fast-flowing streams with coarse substrates like cobble and gravel. Spawning occurs in late spring, often beneath stones. Highly sensitive to siltation and poor water quality, making them valuable ecological indicators.

Lamprey spp. (Brook, River & Sea)

Brook lamprey (*Lampetra planeri*) are non-migratory and fully freshwater. They spawn in gravel beds between April and June and die shortly after.

River lamprey (*L. fluviatilis*) migrate from estuaries to spawn in pebbly riffles in spring.

Sea lamprey (*Petromyzon marinus*) are the largest species (up to 1 m), migrating in May–July to spawn in cobble substrates.

All species lay eggs in constructed nests and produce larvae (ammocoetes) that drift downstream and burrow into silt beds for several years before metamorphosis.

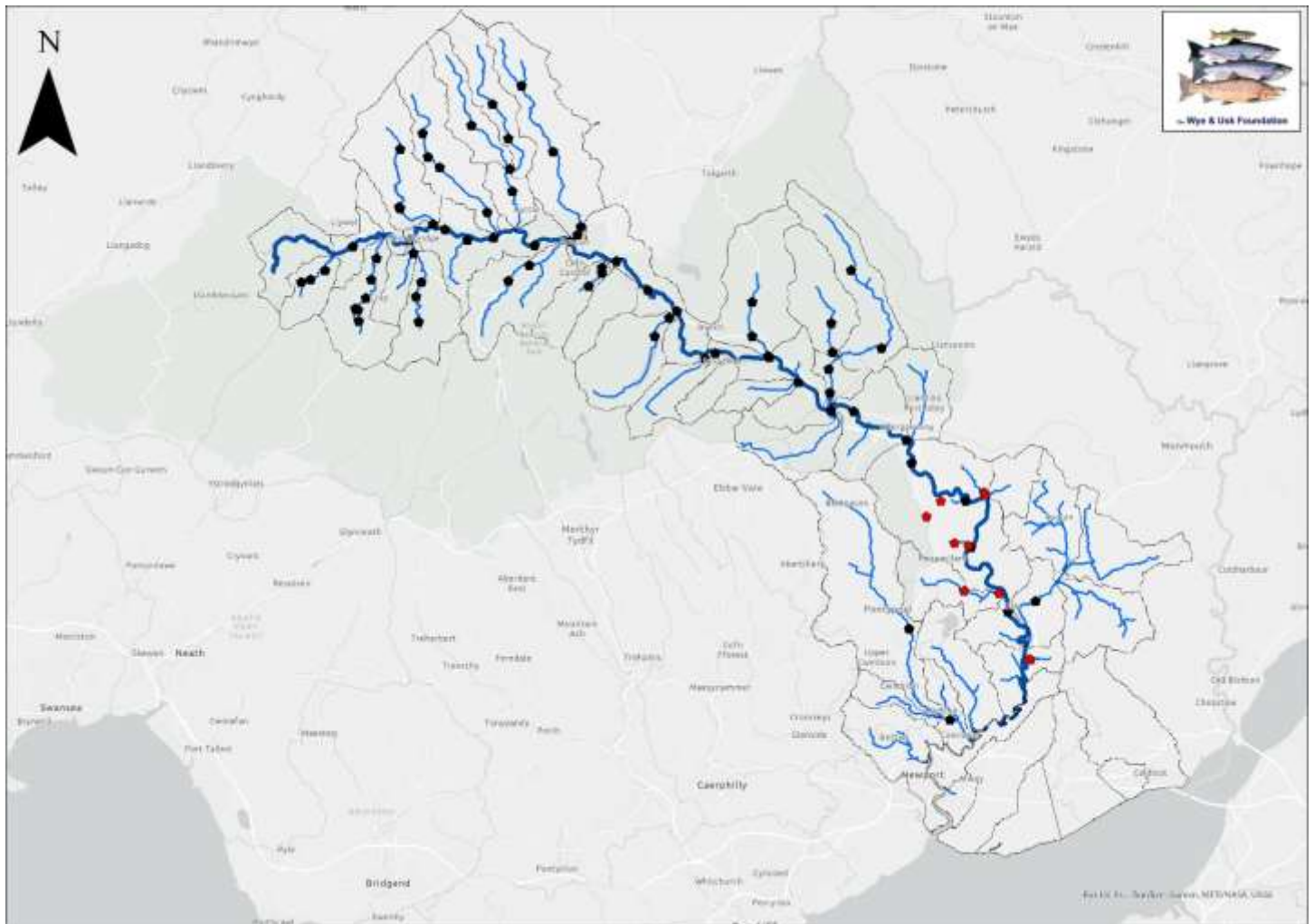


Figure 1 The Usk and its tributaries showing electrofishing sites. The river is depicted by a thick blue line, and the tributaries by a thinner blue line with a thin black line showing the catchment of each. Electrofishing sites sampled in 2024 are shown in black, sites sampled in 2013 are in red.

Methodology

Electrofishing Methodology

Electrofishing is a fish sampling technique that uses controlled electric currents, to temporarily stun fish, allowing them to be captured, identified, and released unharmed. A portable electrofishing unit emits a direct current (DC) or pulsed DC into the water through a positive electrode (anode) and a negative electrode (cathode). When fish enter the electric field, they experience a physiological response known as galvanotaxis, causing them to involuntarily swim toward the anode. This movement is followed by brief immobilisation, enabling capture with hand nets.

There is a range of equipment that can be used to carry out electrofishing surveys, but fundamentally there are two main types: generator-powered units or backpack-powered units.

Backpack electrofishing units are portable systems worn by the operator and are commonly used in small, shallow streams or wadeable river sections. They are lightweight, battery-powered, and ideal for fine-scale, targeted surveys such as riffle assessments. Their main limitation is the need to charge the batteries after extended use, although spare batteries can be easily swapped in. Generator-powered electrofishing units, often mounted on boats or bankside, deliver higher power and are used in deeper or wider waterbodies where greater electrical output is needed to effectively sample fish. They allow for larger-scale surveys, including deeper channels and higher discharge environments, with far less limitation on power consumption, but are far less portable than backpack-powered units. Pros and cons of both equipment types are summarised in Table 1 below.

Table 1: The pros and cons of generator-powered and backpack-powered electrofishing units

Feature	Backpack Unit	Generator Unit
Power Source	Battery	Petrol/diesel generator
Mobility	High (worn by operator)	Limited (bank- or boat-mounted)
Suitable Habitat	Shallow, narrow streams	Wide or deep rivers/lakes
Output Power	Lower	Higher
Survey Scale	Small-scale, fine resolution	Large-scale, higher volume

Due to the scale of the Usk electrofishing survey (currently including over 70 sites each year), the requirement to survey shallow riffles, the need to access remote sites, often by wading or walking through vegetation, and the limited time window, WUF use a backpack-powered electrofishing unit.

Electrofishing Settings and Rationale for Survey Efficiency

WUF uses an EFish 500w backpack unit for all electrofishing surveys, which allows operators to adjust several key settings to optimise fish capture while ensuring safety and efficiency across different river conditions.

Adjustable Parameters:

- **Frequency (Hz):**
This controls the number of electrical pulses per second. During WUF electrofishing surveys, the frequency is set to 40Hz, a frequency commonly used in UK rivers when targeting salmonid species (such as Atlantic salmon and brown trout). This is because 40Hz is high enough to reliably induce galvanotaxis in salmonids, which are moderately responsive to electric fields, whilst also being low enough to affect other common UK freshwater species (e.g. bullheads, stone loach, minnows, lamprey, eels), making it useful for broader community assessments. Furthermore, it helps reduce the risk of injury to fish compared to higher frequencies or alternating current (AC), making it suitable for scientific and conservation-focused surveys.
- **Voltage (V):**
This determines the strength of the electric field. Voltage is set based on measured electrical conductivity of the water to achieve an effective field without causing harm. WUF staff measure conductivity on-site before surveys to adjust voltage accordingly. In particularly low conductivities ($>150 \mu\text{S/cm}$) the electric field's reach and effectiveness may be reduced (E Fish Solutions, n.d.); however, very low conductivities are not a characteristic of the Usk and its tributaries, so this does not present an issue to the Usk electrofishing surveys.
- **Duty Cycle (%):**
This sets the proportion of each pulse during which current is active. Lower duty cycles reduce fish stress, while higher settings may improve capture efficiency. WUF operates electrofishing surveys using a 10% duty cycle, a setting selected to balance effective fish capture with animal welfare. This approach is supported by findings from Miranda and Dolan (2004), who demonstrated that duty cycles in the 10–50% range require the least peak power to immobilise fish, improve sampling efficiency, and significantly reduce the risk of harmful tetany—a condition where intense muscle contractions can lead to injury or mortality. In contrast, narcosis is a reversible state of immobilisation that allows fish to be captured safely without long-term harm. Lower duty cycles also expand the effective electric field while maintaining a safer margin between narcosis and tetany, making them ideal for responsible survey work.

Survey design

Electrofishing surveys typically fall into two categories: quantitative and semi-quantitative. Quantitative approaches involve multiple passes within a defined, enclosed area—often using stop nets—with the

aim of estimating actual fish population sizes. While highly accurate, these surveys are time-consuming, resource-intensive, and often impractical for large-scale monitoring across many sites.

In contrast, semi-quantitative methods such as 5-minute timed riffle surveys offer a more logistically feasible alternative, providing repeatable and consistent relative measures of fish abundance. Though they do not yield precise population estimates, they are useful for detecting presence/absence, identifying relative density patterns, and tracking changes over time. These methods are commonly used by regulatory agencies, such as Natural Resources Wales (NRW) and the Environment Agency, especially in Special Areas of Conservation (SACs) like the River Usk.

The Wye and Usk Foundation (WUF) employs 5-minute riffle surveys throughout the Usk catchment. The method, which standardises the active electrofishing time (excluding netting and processing) to five minutes per site, provides consistent data while enabling, broad-scale coverage. It was originally selected to monitor salmonid juvenile recruitment, as riffles are preferred nursery habitats for young Atlantic salmon and brown trout. These habitats also support a range of benthic species of conservation interest, such as bullhead and stone loach, which tend to seek cover within coarse substrate and are effectively sampled by this method.

Since 2013, WUF's monitoring has broadened to include a wider suite of species, many of which also occupy riffle habitats. However, the survey method has its limitations. Deeper-dwelling species, such as pike, perch, or adult eels and trout, are typically underrepresented, as they inhabit deeper pools, undercut banks, or complex structural cover not accessible via riffle-based sampling.

For salmon and trout a separation has been made between fry and parr in the data. Fry are the early life stage of salmon and trout that have recently emerged from gravel redds after hatching. At this stage, they are small, largely sedentary, and typically remain in shallow riffles close to where they hatched. They primarily feed on small aquatic invertebrates and are highly dependent on clean, oxygen-rich water. Parr are the next developmental stage and are characterised by their larger size and, for salmon, distinctive vertical "parr marks" along their sides. They are more mobile and begin to occupy a broader range of habitats within the river, including deeper water and marginal cover (Dunbar et al., 2014).. Parr are more independent and feed more actively, often competing for territory. In electrofishing surveys, counts of fry indicate the success of the previous spawning season. Counts of parr will relate to the fry numbers of the previous year but will depend upon how good conditions have been for subsequent survival. To classify salmonids into fry or parr, visual indicators are used and the fish are measured; size being a reliable indicator. Eels and lampreys are also measured as indicator of age.

An important caveat of 5-minute riffle surveys is that no stop nets are used, meaning more mobile or pelagic fish can avoid capture by swimming out of the area during the survey. However, this design does not significantly affect sampling of the target species. Juvenile salmonids, bullheads, eels and stone loach tend to burrow or remain motionless when disturbed, making them susceptible to detection.

The survey season is between late June and August, a period chosen to coincide with the stage at which juvenile salmonids are large enough to be effectively detected via electrofishing. By this time, fry have emerged from redds, absorbed their yolk sacs, and begun active foraging. This timing allows recruitment to be assessed before significant autumnal dispersal occurs. However, it is acknowledged that this

period may not align perfectly with the seasonal activity or detectability of all species. Some taxa, particularly those with earlier spawning periods or more cryptic life stages, may be underrepresented.

The late-June to August timeframe also reflects practical field constraints. River and stream levels are likely to be relatively low, improving safety and access, and increasing capture efficiency. The survey window is reasonably wide, allowing for flexibility around weather conditions and operational delays—such as high flows, equipment issues, or logistical challenges. At the same time the aim is to complete any one survey as quickly as possible to minimise stress on fish. High summer temperatures reduce dissolved oxygen levels, increasing vulnerability during capture, so rapid processing and post-survey recovery are critical to fish welfare. Vegetation growth during summer can also interfere with visibility and gear effectiveness in some habitats. Experience has shown that this time window creates an effective balance between fish biology, survey reliability, and practical feasibility.

In summary, while 5-minute riffle surveys are not without limitations, they offer a practical and scientifically sound compromise. They allow the efficient collection of high-quality, repeatable data across a large number of sites and the fish that they target are a major focus of conservation and management efforts in the River Usk.

Site selection and on-site procedure

Electrofishing sites were selected to provide representative coverage of both tributaries and the main River Usk. For the purposes of this report, the main channel refers to the primary course of the River Usk from its upper non-tidal reaches downstream to the tidal limit, distinct from its inflowing tributaries. Initial surveys (2013–2016) were largely restricted to tributaries due to funding constraints, but from 2017 onwards the network expanded to include a greater proportion of main-channel sites, recognising that these reaches support ecologically distinct habitats and species assemblages not captured through tributary sampling alone. While the expanded network provides broader ecological insight, inter-annual comparisons were restricted to sites sampled consistently across the 2016–2024 period.

Following site identification, based on aerial imagery and prior knowledge of suitable riffle habitat, landowners were contacted and access was secured before any survey work proceeded. Sites were only surveyed with prior landowner permission.

All surveys followed a standardised 5-minute timed (active shocking) semi-quantitative method. Surveys consisted of a single pass moving upstream across riffle habitat. The anode was positioned upstream of the cathode to draw fish forwards, while a separate netter collected fish ahead of the anode field. A third team member processed and recorded fish to ensure efficient handling

Surveyors progressed upstream in small increments, sweeping laterally from bank to bank without stepping on unsampled substrate. Because effort was controlled by time rather than area, the length of stream covered varied naturally with channel width: wider main-channel sites required shorter upstream progression to ensure full lateral coverage, whereas narrower tributaries allowed longer upstream distance within the same 5-minute period. If a riffle ended before the timed period was complete, the

team advanced to the next suitable riffle; conversely, if 5 minutes elapsed before the full riffle was surveyed, sampling ceased. This ensured consistent sampling effort across the diverse geomorphological settings of the Usk system.

The Usk is monitored annually by both the Wye and Usk Foundation (WUF) and Natural Resources Wales (NRW) to maximize coverage across the catchment. NRW's electrofishing surveys vary in methodology—ranging from semi-quantitative to fully quantitative—and in the number of sites sampled each year, which means their results are not always directly comparable with those from WUF. However, NRW surveys provide valuable quantitative data at specific sites and offer catchment-wide oversight, including areas not covered by WUF. Where possible, NRW electrofishing data have been incorporated into results and discussion presented in this report. Depending on funding available, both WUF and NRW will carry out a higher number of surveys in certain years to gain a more in depth understanding of fish populations where possible, and this is reflected in the variation of sites surveyed each year. From the electrofishing surveys undertaken on the Usk in 2013, there is comprehensive data available for 10 sites. Now, surveys cover nearly all tributaries of the Usk above the tidal reaches (Figure 1).

This study was undertaken within the funding and time constraints of the project, and the analyses presented here represent the most rigorous interpretation feasible of the 2016–2024 electrofishing dataset and the species included within it. While the report provides robust, evidence-based conclusions, additional time and resources would allow further analytical refinement and expand the scope of inferences that could be drawn.

Results and discussion

The electrofishing dataset maintained by WUF dates to 2013; however, the survey effort became more consistent from 2016 onwards and it is data from 2016 to 2024 that are presented here. Even within this period there are differences between the years in terms of the proportion of main channel and tributary sites that are included, and further analysis will be necessary to determine the importance of these factors.

Table 2 provides data over the years on the number of survey sites and the numbers of fish of each species recorded. For salmon and trout, the data are presented separately for fry and parr. Figure 2 presents the same data in graphical form to highlight the features of the data from different years.

Across the combined 9 years and 736 sites a total of 32,703 fish were captured, recorded and released. The most commonly recorded fish were bullheads (13,524 captures, 25.2 avg detections per site) followed by trout fry (5,260 captures, 10.2 avg detections per site) with the least recorded being lamprey (76 captures, 5.1 avg detections per site) then eel (566, 3.1 avg detections per site).

When looking at the average count of fish per site (when accounting for sites with no detections), there is some variation between species and age groups, with highest average counts being recorded in 2018 (trout fry and parr), 2019 (salmon parr, bullheads, eel, minnow, lamprey), 2020 (salmon fry) and 2024 (stoneloach). Lowest average counts were recorded in 2016 (salmon fry, lamprey), 2017 (minnow, lamprey), 2018 (loach), 2020 (trout fry), 2021 (bullhead), 2022 (trout parr), 2023 (eel, salmon parr).

Table 2: Results for different categories of fish from electrofishing surveys conducted between 2016 and 2024.

Species	Year	No. Sites sampled	No. of fish counted	Avg no. fish per site (only for sites in which species is present)	No. Sites with fish detected	% sites with fish detected
Salmon Fry	2016	143	37	3.1	12	8%
	2017	107	58	7.3	8	7%
	2018	91	167	9.3	18	19%
	2019	60	208	9.5	22	37%
	2020	87	168	15.3	11	13%
	2021	87	499	14.7	34	39%
	2022	113	318	6.9	46	41%
	2023	100	186	8.1	23	23%
	2024	71	964	26.1	37	52%
Salmon Parr	2016	143	291	4.4	66	46%
	2017	107	180	5.1	35	33%
	2018	93	201	5.4	37	40%
	2019	60	114	6.7	17	28%
	2020	87	156	6.5	24	28%
	2021	87	97	3.3	29	33%
	2022	113	83	3.6	23	20%
	2023	100	57	2.0	29	29%
	2024	71	56	2.9	19	27%
Trout Fry	2016	143	803	6.9	117	82%
	2017	107	666	7.7	86	80%
	2018	93	1407	16.6	85	91%
	2019	60	359	11.2	32	53%
	2020	87	86	4.8	18	21%
	2021	87	390	11.1	35	41%
	2022	113	680	11.7	58	52%
	2023	100	360	9.0	40	40%
	2024	71	509	11.6	44	62%
Trout Parr	2016	143	846	7.1	120	84%
	2017	107	711	7.9	90	84%
	2018	93	882	10.0	88	95%
	2019	60	316	9.9	32	53%
	2020	87	210	6.2	34	39%
	2021	87	113	3.2	35	40%
	2022	113	155	3.1	50	45%
	2023	100	138	3.2	43	43%
	2024	71	123	3.3	37	52%
Bullhead	2016	143	2093	18.7	112	78%

	2017	107	1692	20.9	81	76%
	2018	93	2069	25.9	80	86%
	2019	60	980	89.1	11	18%
	2020	87	1570	34.9	45	52%
	2021	87	889	17.1	52	60%
	2022	113	807	15.2	53	47%
	2023	100	1135	24.1	47	47%
	2024	71	2289	42.4	54	76%
Minnow	2016	143	407	17.7	23	16%
	2017	107	0	0.0	0	0%
	2018	93	129	14.3	9	10%
	2019	60	125	62.5	2	3%
	2020	87	620	32.6	19	22%
	2021	87	205	18.6	11	13%
	2022	113	755	26.0	29	26%
	2023	100	326	20.4	16	16%
	2024	71	291	19.4	15	21%
Loach	2016	143	63	7.0	9	6%
	2017	107	26	6.5	4	4%
	2018	93	0	0.0	0	0%
	2019	60	30	15.0	2	3%
	2020	87	291	19.4	15	17%
	2021	87	626	26.1	24	28%
	2022	113	715	23.1	31	27%
	2023	100	556	19.9	28	28%
	2024	71	778	29.9	26	37%
Eel	2016	143	97	2.9	34	24%
	2017	107	47	3.6	13	12%
	2018	93	52	3.1	17	18%
	2019	60	18	6.0	3	5%
	2020	87	56	2.7	21	24%
	2021	87	80	4.0	20	23%
	2022	113	106	3.2	33	29%
	2023	100	34	2.1	16	16%
	2024	71	76	3.0	25	35%
Lamprey	2016	143	0	0.0	0	0%
	2017	107	1	1.0	1	1%
	2018	93	0	0.0	0	0%
	2019	60	51	12.8	4	7%
	2020	87	5	1.3	4	5%
	2021	87	6	6.0	1	1%
	2022	113	9	4.5	2	2%
	2023	100	2	1.0	2	2%
	2024	71	2	2.0	1	1%

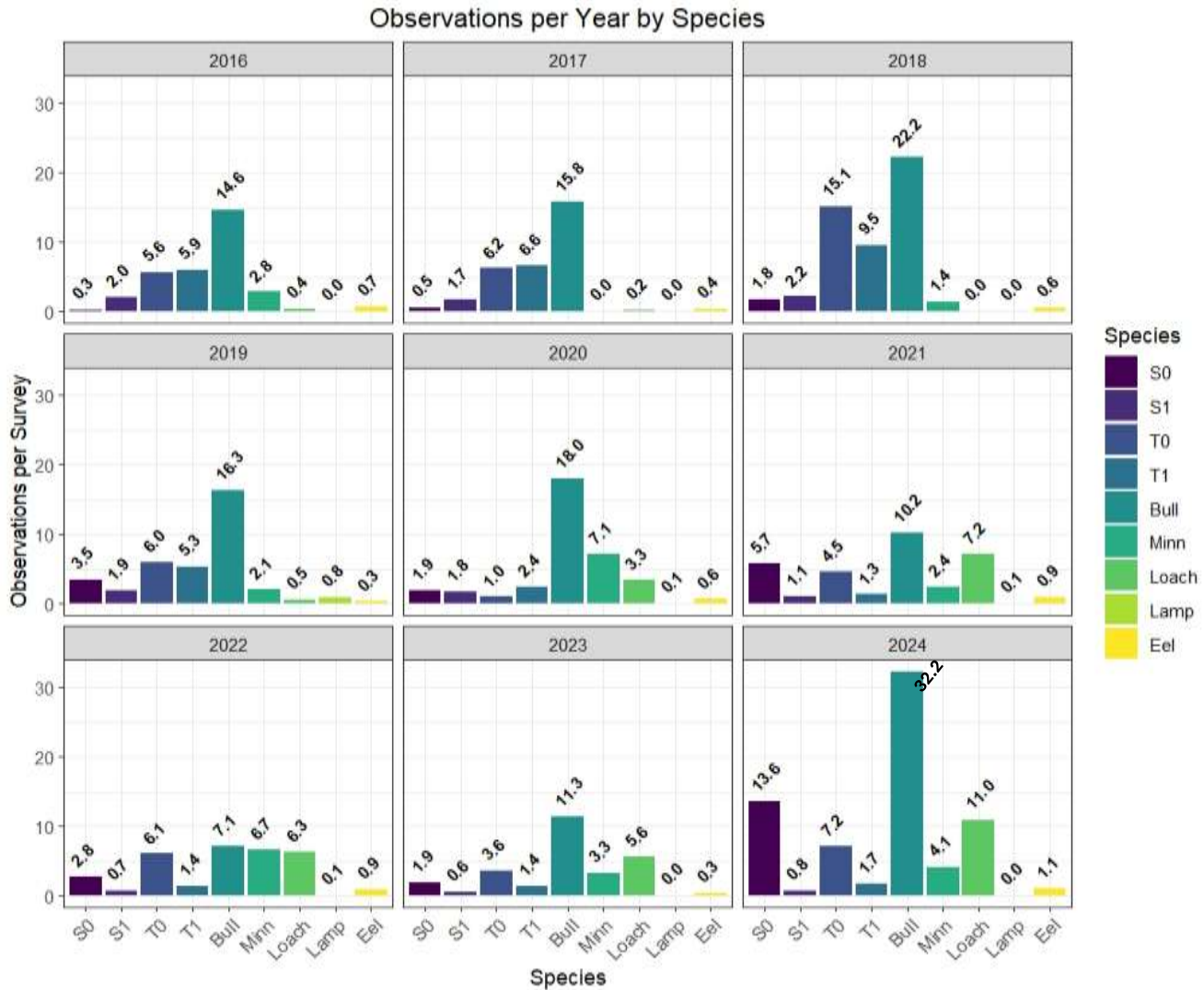


Figure 2: Bar plots of mean number of counts per site for each type of fish per year.

Figure 3 provides pie charts showing the spatial distribution of the various species across the catchment for the two years 2016 and 2024. For both salmon and trout the data for fry and parr have been combined. The figure depicts the preference of salmonids, particularly salmon, to occupy the upper tributaries, bullheads display extensive coverage across the whole river, and stone loach show a strong preference for main river sites. Supplementary information on exact figures per tributary and number of surveys per tributary can be found in Appendix B.

When all tributary data are combined, the proportion of salmon increased notably from around 15% of the total recorded fish in 2016 to approximately 33% in 2024. This shift was driven by substantial

increases in rivers such as the Crai, Senni, Cilieni, Bran, and Ysgir. In contrast, trout, which accounted for roughly 32% of the catch in 2016, declined to about 18% in 2024, with marked reductions in tributaries including the Hydfer, Grwyne Fawr, Camlais, and Tarell. Bullhead remained the dominant species across both years, with its overall proportion rising slightly from 45% to 47%. Minnows showed a decline, dropping from 10% of the total catch to just 4% in 2024, and were not found in the Cilieni. Data from the main Usk channel are not directly comparable, as only one site was surveyed in 2016. See appendix B for supplementary data table.

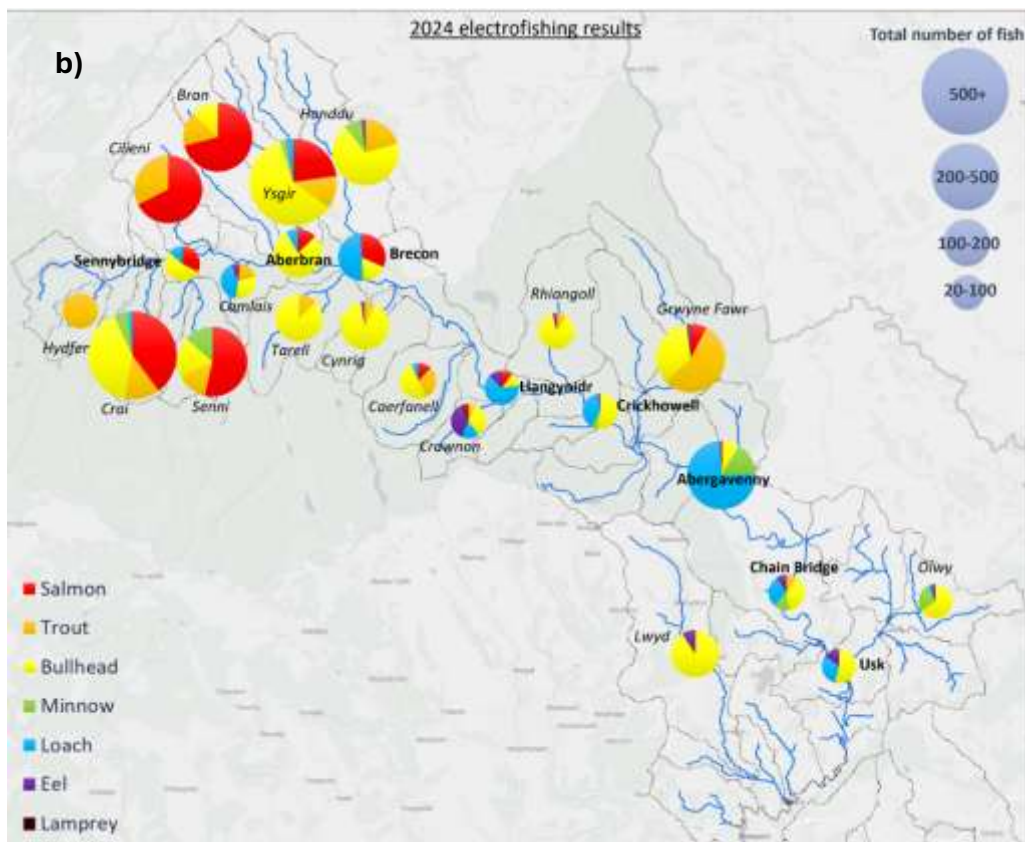
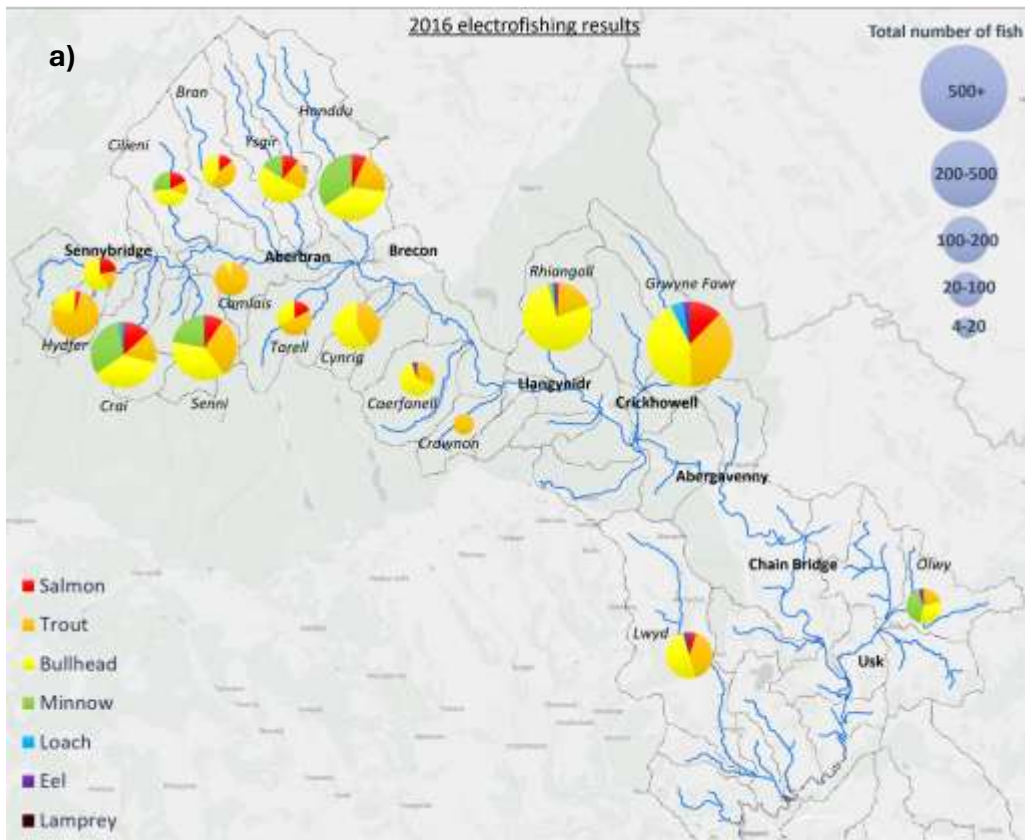


Figure 3 : The spatial distribution and abundance of species surveyed in a) 2016, and b) 2024. The size of pie charts is a measure of the total number of fish recorded at each site. Tributaries are labelled in italics; main channel sites are in bold. Data for salmon and trout are the combined figures for fry and parr

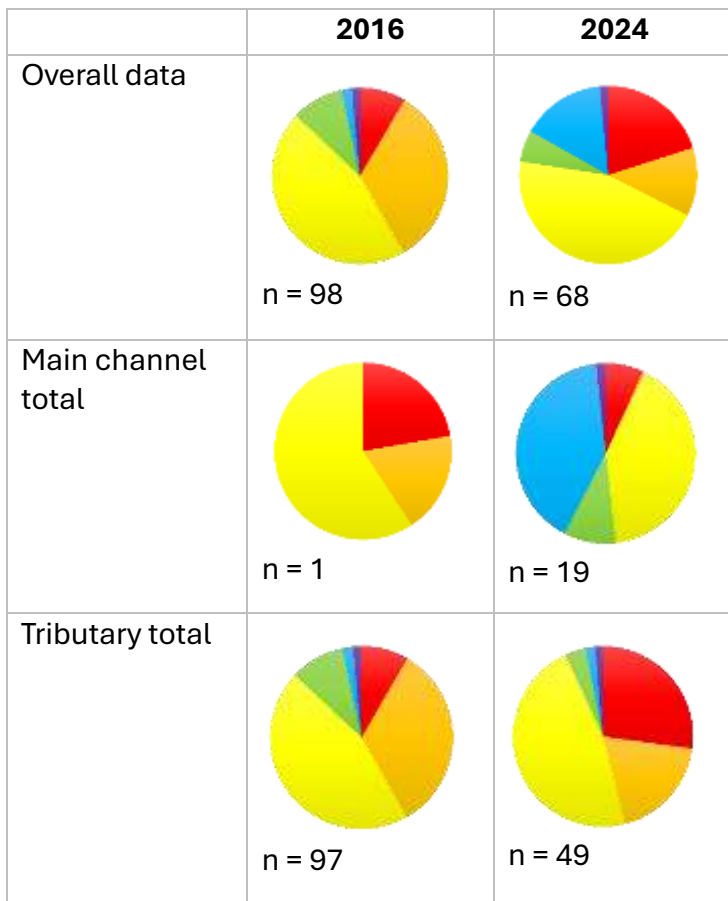


Figure 4 Pie charts showing the proportion of the species' populations in the period 2016 and 2024. n = the number of survey sites, colour codes as in Figure 3.

Table 4 presents information gained from an analysis of the average counts per site for the various categories of fish over the years between 2016 and 2024. It was conducted using a general linear model (GLM).

Table 4: Trends in average numbers of fish in surveys conducted over the 2016-2024 period.

Category of fish	Change per Year (%)	p-value	Trend
Salmon fry	43.2	< 0.05	Positive
Salmon parr	-14.8	< 0.05	Negative
Trout fry	-5.3	0.46	Non-significant
Trout parr	-22.2	< 0.05	Negative
Bullhead	1.8	0.72	Non-significant
Minnow	14.1	< 0.05	Positive
Loach	49.7	< 0.05	Positive
Lamprey	-17.8	0.37	Non-significant
Eel	6.4	0.62	Non-significant

Table 4 shows that the GLM analysis reveals a mixed picture. Salmon fry (S0), minnow and stone loach display significant positive trends in abundance, increasing by 43.2%, 14.1% and 49.7% per year on average. In contrast, salmon parr (S1) and trout parr (T1) show significant negative trends, with average annual declines of 14.8%, 22.2% respectively ($p < 0.05$).

Meanwhile, trout fry (T0), bullhead, lamprey, and eel exhibit non-significant trends, with low annual changes and p-values above 0.05, indicating no evidence for a consistent directional shift.

Performance of the different Species

Bullhead (*Cottus gobio*)

Bullhead had the highest average count per site in every year of the survey (Table 2, Figure 2). Also it was recorded at a higher proportion of survey sites than any other category of fish in 2020, 2021 and 2024 (Table 2). This was a particularly notable finding, given that in his 2021 paper, Mawle comments that a 2018 NRW study had reported for bullheads that 'less than half of the SAC units (44%) had an annual mean density that met the target'. Also Yeomans *et al.*, 2008 had reported on evidence that bullheads was declining throughout Europe. In our study bullheads were consistently found across both the headwater tributaries and main channel sites. This broad distribution highlights their resilience and adaptability to a range of habitats. Their dominance in the dataset may also reflect their non-migratory life cycle and limited movement behaviour; Knaepkens *et al.* (2005) observed that 61–72% of individuals move less than 10 metres, with a maximum observed range of 270 metres. Cowx and Harvey (2003) support this by suggesting that discrete, genetically distinct populations exist between tributaries due to a lack of intermixing.

Statistical analysis was undertaken to explore whether bullhead abundance was negatively associated with salmonid populations. However, following analysis through an ordinal logistical regression model, no statistically significant relationship was found (Appendix A). This therefore does not provide any evidence for the idea that low salmonid abundance can be attributed to competition with bullheads. Rather, the two species are likely coexist due to similar habitat preferences. Both require cool, well-oxygenated water with clean substrate, but Tomlinson and Perrow (2003) note that bullheads may tolerate higher levels of pollution than salmonids, possibly explaining their success in areas where salmonids were not detected ,

Bullhead abundance may also be influenced by reduced predation pressure. Adult trout are known to prey on bullheads (Maitland, 2004) and it is possible that a relatively low density of adult trout across the catchment may be allowing bullhead populations to thrive.

Stone Loach (*Barbatula barbatula*)

Stone loach is characteristic of the Usk but it is not a SAC species and its populations have not been the subject of systematic study. The data presented here are thus of special interest. Loach was the third most abundant species recorded in 2024, accounting for 15% of the total catch (Figure 3). They were primarily found in the main Usk channel and lower reaches of the catchment, particularly around Abergavenny. In 2016, loach only made up 1.8% of the total catch; however, this figure is not representative, as only one site on the main channel was surveyed in that year. As shown in Figure 3b and Table 3, stone loach are primarily associated with the main river channel, and their high numbers in 2024 may well more comprehensive sampling in those areas.

Stone loach are benthic species that favour clean, coarse substrates with moderate to fast flow, often associated with shaded environments and moderate discharge (Nilsson and Persson, 2005). Their distribution also reflects a degree of pollution tolerance. Unlike salmonids, they are capable of surviving in low oxygen conditions and drought through their remarkable ability to absorb oxygen through their hindgut by gulping air (Inland Fisheries Ireland, 2025), a trait which enhances their survival in degraded habitats, and is a likely explanation for their presence where salmonid species were absent.

Analysis of data revealed a significant increase in abundance of stone loach between 2016 and 2024 (Table 4). To investigate potential factors influencing this increase, WUF investigated inter-specific relationships and found documented links between stone loach and trout populations in literature, suggesting that stone loach and juvenile trout can coexist (Nilsson et al., 2010). However, our results did not support a strong positive spatial relationship between the two species. In fact, their distributions were largely separate (Figure 3). Having observed the distinct difference in distribution range, a decline in trout fry population was theorised as a potential explanation; however, analysis revealed no significant decline in trout fry between 2016 and 2024 (Table 4) and therefore this theory was disproved. Nilsson et al. (2010) also observed a negative relationship between stone loach and adult trout, due to predation of adult trout being a limiting factor for loach success. Analysis did reveal a negative relationship in adult trout between 2016 and 2024 which is a possible factor in the increase in stone loach, due to a decrease in predation. However, the survey methods are not designed to accurately assess adult trout numbers and therefore, despite the significant decrease in the recorded results, further investigation would be needed to prove this link reliably. Furthermore, although the data analysis controlled for the number of sites, there is a possibility that with the addition of sites over time, the more recent years may have a skew towards more preferential sites for stone loaches. A number of the sites added are in the lower parts of the Usk Catchment (Figure 3) where stone loaches were observed more frequently.

Salmon (*Salmo salar*)

In the light of the concerns about salmon populations over the past decade as outlined in the introduction, WUF's results were moderately encouraging. Salmon fry results were alarmingly low in 2016 and 2017 (Table 2), only being detected at 9% of sites. However, despite fluctuating numbers across years, WUF found a significant increase in salmon fry between 2016-2024 (Table 4). This was partly due to good results in 2019 and 2021, but especially to the large spike in fry recorded in 2024 (Figure 2). Maps of the data from 2023 and 2024 (figure 5) showed that the most substantial increases in fry numbers occurred in the Bran and Senni tributaries with mean increases of 32 and 23 %, respectively. More modest gains were observed in the Crai, the main channel upstream of Llangynidr, and the Grwyne Fawr.

When records for salmon fry in 2024 are compared with results from 2016, a more widespread increase across almost the entirety of the Usk's headwaters can be observed (Figure 5).

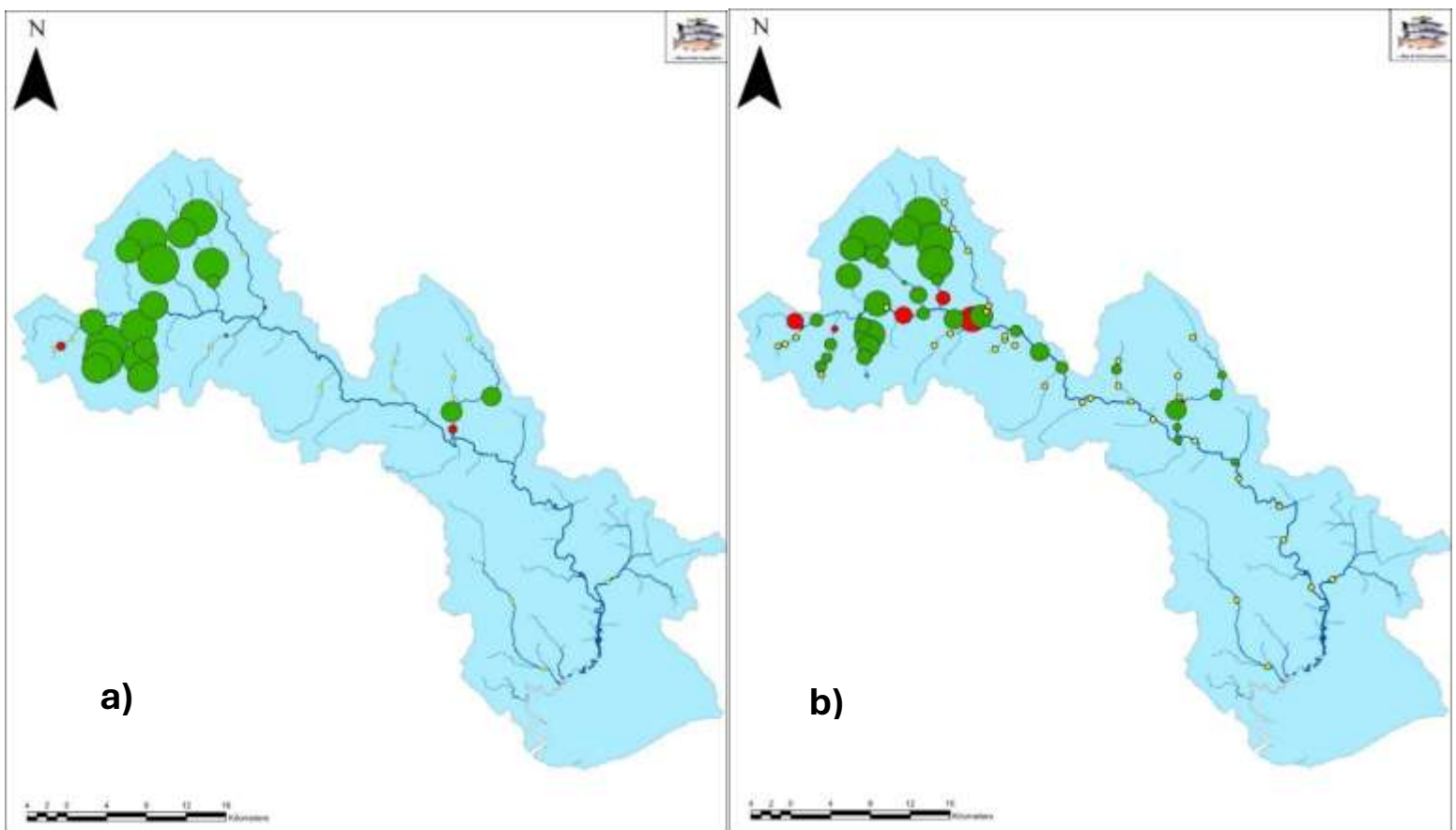


Figure 5: Change in salmon fry numbers surveyed at each site from **a)** 2016-2024 and **b)** 2023-2024. A green point denotes an increase, a red point denotes an decrease, and a yellow point denotes no change. The size of the point is proportional to the scale of change, following a logarithmic transformation

Salmon fry results in 2017 and 2018 are probably indicative of the challenges that Atlantic salmon have been facing in recent years. Rising air temperatures have led to warmer river conditions, which reduce dissolved oxygen levels and increase physiological stress for cold-water species such as salmon and trout (Wye & Usk Foundation, 2018). In tandem, increasingly erratic weather patterns have brought both prolonged droughts and more intense rainfall events. Low flows not only concentrate pollutants but can also hinder fish migration and increase vulnerability to predation. Conversely, heavy rainfall and flash floods can scour salmon redds, (Mawle, 2021; Galloway Fisheries Trust, 2023). Additionally, high turbidity can compact gravel, making it harder for salmon to dig redds, and may cause gravel to settle over the eggs, leading to anoxic (oxygen-deprived) conditions that inhibit development (Collins et al., 2017).

By contrast, the 2024 results are heartening as they demonstrate the salmon’s capacity to recover under the right conditions. One possible explanation for the peak in salmon fry numbers observed in this year is the unusually gentle rainfall during the winter of 2023/4, when the eggs would have been laid. Although overall rainfall was high, there were only two hours of ‘very heavy’ rain, >8mm in 15. The lack of such intense rainfall probably created more favourable conditions for egg survival and maturation. Another possible factor is that numbers of fish returning to breed may have been higher than was initially thought.

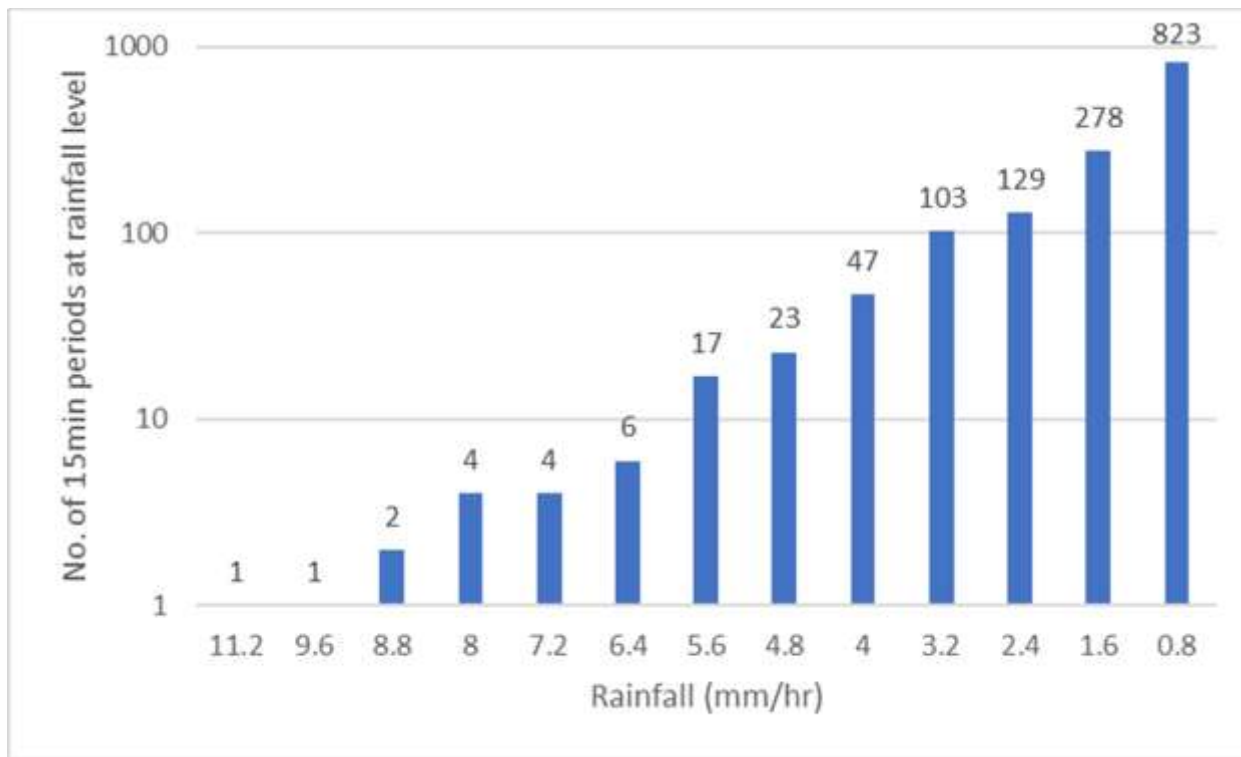


Figure 6: Bar plot showing rainfall data from winter 2023. Frequency of 15 minute rainfall intervals of different intensities are displayed.

Additional evidence comes from a fish counter trialed on the lower Usk, which operated for two weeks in June and two weeks in October (Mawle, 2024). During this limited period, it recorded 414 salmon entering the river. Based on monthly rod catch data, WUF understand that Usk salmon now run almost

exclusively between mid-May and July. It is therefore highly unlikely that 65% of the estimated total salmon run occurred within less than 20% of the known migration window, especially given that water levels remained favourable throughout the season. There is also a well-established link between the number of smolts leaving a river and the number of adult salmon that return. In 2021, spring flows were particularly favourable, resulting in high smolt survival (70%) as confirmed by NRW tagging data (Mawle, 2024). Since the majority of Usk salmon are two-sea-winter fish, many of the smolts that left the river in 2021 likely returned as spawning adults in 2023 and therefore are responsible for the peak in salmon fry we saw in 2024 (figure 3, figure 4). Comparably, in 2022 during low flows, only 25 percent survived the migration downriver (Mawle, 2024). This may have implications for the 2025 survey of salmon fry population and one could hypothesise that salmon fry populations in 2025 will be lower than in 2024.

In contrast to the increase in salmon fry, analysis indicated a slight but significant decrease in salmon parr between 2016-2024. The electrofishing surveys are designed to target fry, *the juvenile salmonids*, which are considerably less mobile than parr and favour the riffle habitat that WUF survey far more than parr. Consequently, it is expected that parr would be underrepresented in the results due to their ability to escape capture, and therefore these surveys may not be an entirely accurate representation of changes in parr numbers. However, there may be other factors influencing salmon parr populations: Natural Resources Wales (2023) noted that “populations of certain fish-eating birds, notably the cormorant (*Phalacrocorax carbo*) and goosander (*Mergus merganser*), have increased in the UK in recent decades, and these birds are now widely distributed across Wales”. The parr captured in WUF’s electrofishing surveys are from the previous year’s spawning cycle, meaning that they have grown from fry and survived in that habitat for a year or more. One of the primary threats to salmon fry are fish eating birds, therefore it is likely that an increase of fish-eating bird populations would result in a greater number of salmon fry being predated before they can reach the parr stage of their life cycle. This could explain why results indicate good numbers of newly spawned fry, but comparatively poorer numbers of parr that have survived from the previous year.

Brown Trout (*Salmo trutta*)

Although both trout and salmon are of the “*Salmo*” genus and share similar preferences for breeding habitat, results indicated that there was a slight difference in their spatial distribution across the Usk catchment. Although trout make up a smaller proportion of overall count compared to salmon in 2024, 18% and 33% respectively (Table 3), trout were more widely distributed than salmon, with trout fry being detected in more tributaries than salmon fry across all years sampled, and notably lower in the catchment (Figure 3). This broader distribution may be explained by trout’s greater flexibility and tolerance to a range of temperatures and slower flows compared to salmon (Heggenes et al., 1999).

Mawle (2025) comments on a general decrease in brown trout in the River Usk over time, with numbers a third of what they were in 1980. In the last NRW WFD assessment (2021), 10 of 32 tributaries failed to meet "Good Ecological Status" due to poor trout populations, with the failures occurring in the middle and lower Usk catchment. Although our results show no statistically significant decline in trout fry between 2016-2024 (table 4), their absence from lower tributaries such as the Lwyd and Olwy in 2024 is

notable (Figure 3), especially given that 73 and 20 individuals were recorded at these sites in 2016, respectively (Appendix B). This decrease in trout in the tributaries lower in the catchment corroborates Mawle's (2025) findings but may reflect a reduction in the number of survey sites in these areas or a deterioration in habitat quality, both of which could influence detection and local abundance. Mawle (2025) also notes that only 14% of trout sampled in 2022 were under 30cm, suggesting a lack of recruitment. While catch-and-release policies may explain the presence of larger individuals, they may also obscure the decline in juvenile abundance.

The Hydfer tributary provides an interesting case study. Despite its proximity to the productive Crai, only 61 trout were recorded in 2024, and no other species were found. This is likely due to natural physical barriers, such as waterfalls and bedrock shelves, which prevent access by migratory species. The Hydfer lies within a notably steep valley, featuring abrupt drops and extensive bedrock formations that restrict upstream passage. Trout, with their superior swimming ability, may have colonised during high-flow events or before these features became fully impassable. This latter explanation may also account for the absence of other species, such as bullheads or stone loach, which are less mobile and less capable of traversing such obstacles. However, results from 2016 indicate the presence of salmon and bullheads in the Hydfer (Figure 3), which are no longer present in 2024. This could be due to the decrease in sites sampled on the Hydfer in 2024 (Appendix B), but 2 of the 3 sites sampled in 2024 had previously had bullheads recorded in 2016 and therefore the cause of these changes may be more complex.

European Eel, Minnow, and Lamprey

In 2024, eels made up only 1.6% of the total fish recorded (Figure 3), with highest numbers observed in the Crawnon tributary (11) and the Usk main channel near Usk town (8). In 2016, eels accounted for 1.5% and table 4 shows no significant change in numbers over time. Despite their low presence in survey results, this likely underrepresents true abundance. Electrofishing methods and site selection were not optimised for eel habitat, and juvenile eels are often cryptic and inhabit complex structures.

In 2023 the average size of eel caught was 23.6cm, with 21% of eels caught being elvers, recently arrived juveniles less than 13cm long (Ness District Salmon Fishery Board). In 2024, the average size of European eels recorded was 18 cm, of which 30% of individuals surveyed were elvers. Sizes of captured eels were not readily available for earlier years, but these data could be sought out in an extended study. As previously discussed, the equipment used is selective and will select for larger eels, so it very likely that the elver population is underrepresented; nevertheless, these results do indicate that there is not only a resident population of adult "yellow eels", but also regular migration of juveniles into the River Usk.

Eel populations have plummeted across Europe, and the Severn River Basin District (which includes the Usk) reported a 50% reduction since 2009 (Defra, 2018). NRW data from 2014–2016 estimated silver eel output from the catchment at just 3% of pre-1980 levels. Eels face distinctly different pressures to other fish in the River Usk, due to their catadromous life cycle, migrating to their birthplace in the Sargasso Sea to reproduce and newly spawned young then migrating to rivers, where they will stay for the vast majority of their life. Recovery is hampered by migration barriers, overfishing, and poor recruitment from oceanic

spawning grounds. However it is encouraging that our results do not show a narrative of further decline in the Usk over the last 10 years.

In 2024, minnows were recorded in several tributaries including the Crai, Senni, Honddu, and Olway, as well as at main channel sites such as Crickhowell, Abergavenny, and the Chain Bridge. Compared to 2016, minnows made up a smaller proportion of the fish community in the tributaries, while their relative abundance increased in the main channel. However, this conclusion may be skewed by the increased number of sites in the main channel in 2024 (appendix B). Although native to Wales, their competitive advantage in degraded systems may threaten more sensitive species like salmonids. Reemeyer and Chapman (2024) showed that minnows maintain thermal performance under hypoxic stress, a key advantage in warming, oxygen-poor rivers.

Lampreys were rare in the 2024 survey, with only two individuals recorded (both in the Crawnnon). Numbers have been consistently low since 2016 with the exception of 51 counted in 2019 (Table 2). Barriers to migration, sedimentation, and spawning habitat loss are likely contributors. Clemens (2024) notes that altered flows and siltation can degrade lamprey redds and nursery areas. Furthermore, electrofishing is ineffective at detecting larval lamprey (ammocoetes), which may explain the low recorded numbers.

Conclusion

Electrofishing surveys in the riffle habitats of the Usk catchment reveal a complex and dynamic fish community shaped by species-specific life histories, habitat characteristics, and long-term anthropogenic pressures. This report presents data and analyses on both temporal and spatial scales. Bullheads are the most abundant species, thriving due to their limited mobility, tolerance of moderate pollution, and discrete, localised populations. Juvenile salmonids display distinct spatial patterns likely influenced by spawning habitat preferences and migratory capabilities, with trout showing greater habitat flexibility than salmon. A particularly encouraging finding was the increase in salmon fry in 2024, likely linked to favourable spawning conditions and prior smolt survival, suggesting potential for population recovery if such conditions persist. Overall, our results underscore the struggles of many species in the Usk since the 1980s but highlight the resilience of these fish and their ability to bounce back, as seen in our recent salmon fry results.

This assessment reinforces the importance of maintaining and restoring habitat connectivity, monitoring species-specific ecological requirements, and considering both historical and contemporary factors shaping fish communities in the Usk catchment.

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Appendix A

Analysis of grades for salmon fry and parr and trout fry and parr against bullhead count at each site in 2023 and 2024 showed that there was no significant relationship between bullhead abundance and the grade each site was assigned (Table A). Grades of salmon and trout were determined according to findings by Crozier & Kennedy (1996) and provide a representation of the condition of the population based on results of semi-quantitative electrofishing surveys.

Table A: Results of ordinal logistical regression models comparing bullhead count to the assigned grade for each site in 2023/24. The model shows that bullhead count has a negligible, non-significant effect on the likelihood of being in a higher grade ($\beta = 0.0052$, $SE = 0.0107$, $p = 0.625$).

Species	Year	
	2023	2024
S0	0.62	0.42
S1	0.20	0.73
T0	0.06	0.61
T1	0.16	0.61

Appendix B

Table B: Comparison of species' populations between 2016 and 2024, supplementing Figure 3 and table 3. n = number of survey sites on a respective tributary.

	n		Salmon		Trout		Bullhead		Minnow		Loach		Eel		Lamprey	
	2016	2024	2016	2024	2016	2024	2016	2024	2016	2024	2016	2024	2016	2024	2016	2024
Main Usk	n=1	n=19	6	121	5	7	16	727	0	167	0	721	0	31	0	0
Hydfer	n=6	n=3	5	0	96	61	28	0	0	0	0	0	0	0	0	0
Crai	n=3	n=5	29	224	35	73	80	226	70	29	6	10	0	0	0	0
Senni	n=12	n=4	40	159	129	41	162	57	92	40	1	0	1	0	0	0
Cilieni	n=3	n=4	13	156	10	75	31	0	20	0	0	0	0	0	0	0
Camlais	n=3	n=1	0	1	93	9	6	15	0	0	0	20	0	3	0	0
Bran	n=3	n=4	11	196	34	44	33	36	0	0	0	0	0	0	0	0
Ysgir	n=5	n=5	14	139	27	74	64	368	20	14	0	17	0	0	0	0
Tarell	n=4	n=2	11	0	32	24	21	163	0	0	0	0	0	0	0	0
Honddu	n=5	n=4	18	0	52	71	100	237	90	30	0	0	0	7	0	0
Cynrig	n=4	n=3	0	0	47	10	68	132	0	0	0	0	0	4	0	0
Caerfanell	n=2	n=2	0	8	12	20	25	34	0	0	0	4	2	0	0	0
Crawnon	n=2	n=1	0	0	17	2	0	10	0	0	0	5	0	11	0	2
Rhiangoll	n=11	n=2	5	1	89	7	369	78	10	0	4	0	8	3	0	0
Grwyne F.	n=26	n=6	141	15	419	112	493	71	0	0	55	0	30	4	0	0
Olway Bk	n=4	n=1	0	0	20	0	32	27	40	11	0	1	5	2	0	0
Lwyd	n=4	n=2	9	0	73	2	90	108	0	0	0	0	8	11	0	0