Chalk stream electrofishing

A Piscatorial Society review of its role in fisheries research & management

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Acknowledgement

Thanks to Stephen Gregory, Senior Statistician at the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) for his extensive editorial help.

Electrofishing

Electrofishing is the use of electricity to capture or control fish. It was first used in rivers over 100 years ago to create fish barriers, and when improvements to the technology emerged in the 1940s the Society began to deploy it as a valuable tool in fisheries research and management. Whilst there are no concise descriptions of the technique to inform non-scientists, which has led to this review.

Although primarily a fishing club, the Society has a long history of undertaking applied research designed to provide a scientifically robust understanding of the effects of our river management activities on our waters.

These activities include river restoration, landscape re-naturalisation, bankside and fishing access policies, stocking policy, conservation and predator control – and the effects of our research have been tangible. For example, we stopped culling grayling and pike many years ago and have changed our river management practices to provide grayling habitat in addition to that for wild trout (see *The Wylye Grayling & Trout Study* below). Our research-driven approach affirms our standing as a serious, professional and progressive fisheries organisation – and informs our partnerships with the owners of such waters as the River Anton and the Grange Estate.

We continually assess our fisheries management strategy, representing a significant investment of time and money, to manage priorities, focus and value, and this review derives from a report on the role of electrofishing in the research projects we have initiated on our waters.

In the following pages you will find:

- Why we use the technique; how it works; how we study the fish; the investment.
- Two Society projects for which it is a vital tool, and their outcomes
- The background – a very brief history of the technique, its potential dangers to (both fish and humans).

Further reading:

Dart, J., J. McGill, R. Wellard and D. Watson. (2024). “Developing and maintaining world class chalkstream fishing: a long tradition of evidence-based fisheries management.” *Piscatorial Society Reviews*, from https://thepiscatorialsociety.net.

Mann, R. H. K. (1985). “A pike management strategy for a trout fishery.” Journal of Fish Biology 27(sA): 227–234.

Why we use electrofishing

Where we need to sample fish populations, electrofishing is simply the best technique available. Alternatives are: netting (which is species-indiscriminate), snorkelling (which is difficult to use in shallow fast water with variable bottom substrate and weed), and bankside observation (which is only suitable for small clear waters). Studies have shown that electrofishing provides better population estimates than these other methods – with fewer manpower requirements and site preparation. (Beaumont 2016).

Our research involves 'fully quantitative' electrofishing population surveys. This requires that a closed section of stream is surveyed by electrofishing multiple (usually three) times – fish captured in each survey are held in holding tanks (usually for 30 to 120 minutes), and the successive reduction in numbers of fish captured across the surveys is used to estimate the true population size using established mathematical models.

How it works

All our staff, and those of the GWCT and Southampton University, have been trained in electrofishing. Most have been trained by Bill Beaumont, a former GWCT employee, who has written the reference book on electrofishing for research. He has been widely endorsed as an electrofishing expert and trainer for the Environment Agency, Natural Resources Wales, Inland Fisheries Ireland, and others.

Further reading:

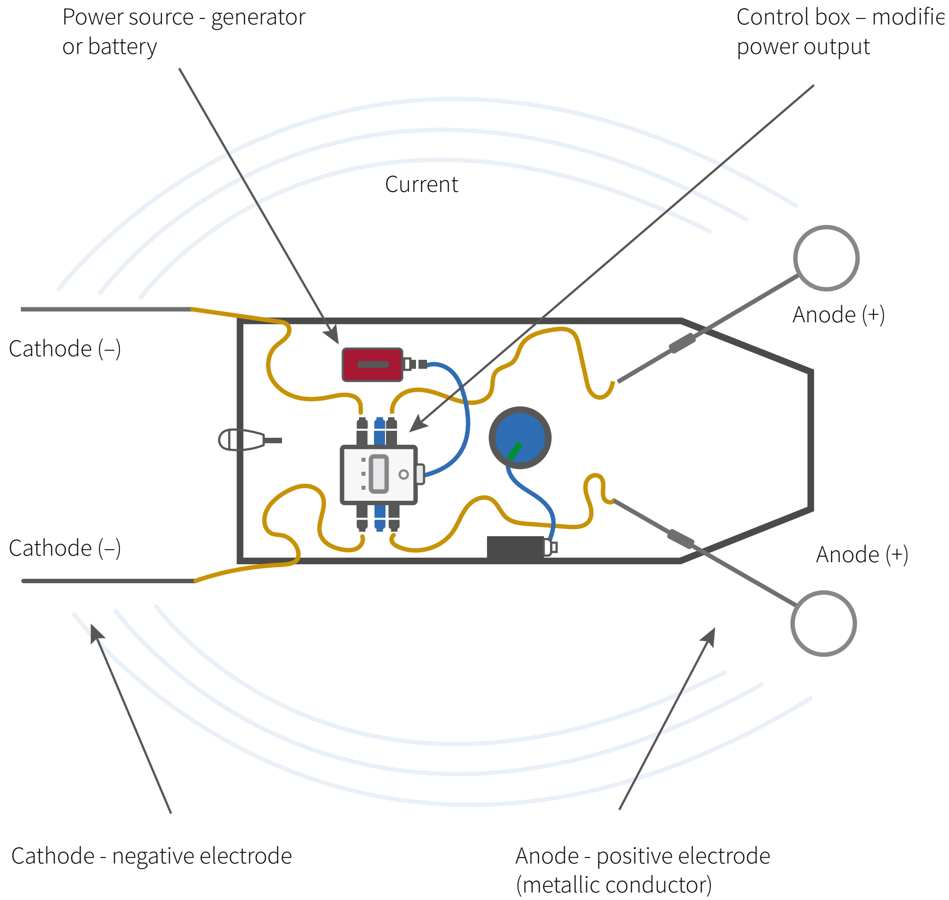
Beaumont, W. R. C. (2016). *Electricity in fish research and management* : theory and practice. Chichester, West Sussex, UK; John Wiley & Sons, Ltd.

Catching the fish

A generator provides power to the control unit. This controls current to the anode (positive electrode) to which fish are attracted by electrotaxis (movement towards electricity). Algorithms and experience are used by the operator to set the control unit to provide pulsed DC with power, current, frequency and waveform adjusted to optimum levels for the target fish species and water conductivity. The diameter of the ring-shaped anode can be altered to optimise the electric fields in relation to the size of stream. The cathode is usually copper or steel braid. Immobilised fish are caught in hand nets.

Depending on the situation, the electrofishing equipment is placed either on the riverbank or in a BIC boat (a lightweight tender). The figure on the right shows a typical setup when electrofishing using a boat on wider rivers, such as for our projects (only one cathode is used in our system). Pulling the boat or, on deeper stretches, working directly from the boat, the operators survey the river in an upstream direction, electrofishing the river representatively, ie allocating effort proportionately, or strategically by targeting effort to maximise fish captured. The survey is repeated multiple (usually three) times with effort allocated similarly between surveys.

Our sites are re-fished annually because we are doing longitudinal surveys. We evaluate two 100 metre stretches at each site. Fish escape is prevented on each stretch by using stop nets at the upper and lower boundary. Stop nets are anchored on both sides of the river and mid-channel using five-foot steel pins.



The photo shows the stop nets at the top of the stretch. One operator is holding the insulated orange handle of the anode, two are netting fish, one is managing the holding bin and another holds the yellow power cord from the generator, which on this occasion is on the riverbank (out of view downstream).

The photo gives another view in which our Keepers (Craig Dawson, Stuart McTeare and Joe Emmett) are working the equipment with some additional help.

This photo shows the boat used in deeper water with, from left to right, a netsman, an anode operator, a red generator with leads going to the control box (just visible to the right of the generator) and with leads from that to the cathode (downstream) and to both anode operators. The second anode operator is to the right of the control box

with another netsman and the green holding tub behind. The boat is pulled along by assistants on each bank.

During electrofishing, anode and net operators minimise the length of time that fish are held in the electric field, and how long they are out of water following capture. Anode operators draw the anode away from immobilised fish to avoid anode contact with fish. Immobilised fish are netted quickly and transferred to the temporary holding bins.

The technique is not used in extremes of temperatures. The maximum water temperature for salmonids is 18C.

Electrofishing is carried out in an upstream direction so that any fish not captured are driven ahead of the fishing team and can move back downstream of the boat or seek cover in the margins, reducing repeated exposure to the electric field.

A workstation is set up at each stretch for species identification, length and weight measurement and, depending on the project, for *visible implant* (VI) or *passive integrated transponder* (PIT) tagging (see descriptions of these below). A scale may be taken for scale readings for age determination and growth measurements.

The photo shows our Southampton University PhD student and her team on the Anton.

Below are photos of pike, bullhead, minnow, salmon parr, stone loach (with the barbels) and brown trout, taken from an electrofishing survey

How we study the fish

This is done by trained staff having the appropriate EA and Home Office licences. Fish are anaesthetised chemically using an authorised anaesthetic administered at a level appropriate for the intervention.

Length & weight

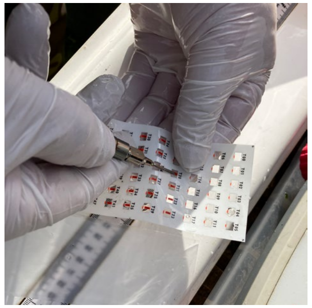
Although the numbers captured are used to provide the population density, we need their length and weight as a minimum to establish the mix of year classes and the biomass. Photo shows a trout being measured

Scale readings

Scale readings are used in some studies. The scales are removed with fine tweezers (left photo) and transferred to a storage envelope (right photo). Scale readings provide accurate data on the age and seasonal growth rates over time for individual fish.

Fish tagging

Fish tagging is used in most of our studies using VI tags. These identify individual fish if subsequently recaptured. This helps to evaluate population stability, individual growth rates, and fish movement.



VI tags (photos above left to right) are tiny & thin, individually coloured and numbered. They are inserted under the skin behind the eye.

PIT tags use the same technology as the “microchips” used in pet dogs and cats. Each PIT tag is a small, pill-shaped cylinder of glass that houses a radio transponder containing a unique code. These do not require a battery but respond to a scanner connected to a reader to identify an individual fish. PIT tags are used when we wish to track fish movement, without the need for recapture, as they can be detected by using a mobile antenna in the study area.

The photo (next column, left) shows PIT tags, in the kidney dishes, and an incision being made in an anaesthetised trout for tag insertion into the abdominal cavity. The photo (next column, right) shows a PIT tag reader in use to identify an individual grayling.

Investment

To run the **Wylye study**, which takes three days each year, we partner with the Grayling Research Trust (GRT), who provide some funding, and the Game & Wildlife Conservation Trust (GWCT), who have the Home Office licence for fish anaesthesia and PIT tagging.

The GWCT also obtain Environment Agency permission to survey fish using electrofishing and provide staff: three for fieldwork, fish tagging consumables and measurement equipment; and one for scale reading, data management and data interpretations – including statistical analyses.

The Society provides the electrofishing equipment, three full-time trained staff and three contractors.

The Anton studies take five days each year. Here, we partner with Southampton University who carry out the same roles as the GWCT for the Wylye study, but with one senior staff member to supervise the

PhD student(s), additional student assistance and the fish research equipment.

Like the GWCT, they maintain the records and carry out the analyses. The Society has the same staff provision as for the Wylye study.

Southern Water have recently agreed a three-year grant to the Society which includes our Keepers' time and covers much of our research costs.

On the following pages we outline two of the major Society projects in which electrofishing has provided critical research information.

The Wylye Grayling & Trout Study

This study has provided the longest data series for European Grayling in any country

Begun in 1996, the study is a collaborative project between the Piscatorial Society, the GWCT and the GRT. Originally focused on grayling, trout have been included since 2003 when the surveys were semi-quantitative – since 2009 the surveys have been fully quantitative. The same seven sites are surveyed annually in the autumn at Parsonage, Upton Lovell, Boyton, Ginger Piggery, Lower Knook, Upper Stockton, and the Stockton Restoration reach (monitored since restoration in 2016-7).

The results have been widely published and have been cited in the GRT's seminal publication on the conservation, ecology and management of European Grayling. (see Further reading)

The two most recent analyses have informed the way in which we manage our fisheries to promote grayling growth and survival. Extreme changes in river flows are poor for grayling survival overall, but with effects that are different for different age classes.

This demands the promotion of diverse habitat with meanders and backwaters to provide a heterogeneous flow environment. Impounded reaches are ideal for adult grayling where they can be retained. They are often lost with restorations aimed at promoting trout, since they have 'naturally' limited growth of macrophytes (ie Ranunculus) due to deep water or shading by the canopy. Increasing canopy cover by a programme of south bank tree planting and/or adjusting the management of existing trees reduces macrophyte cover whilst providing shade that alleviates the high summer temperatures. This is important for grayling, which are at the southern limit of their UK distribution in our southern chalk streams.

A current use of these data is an analysis of the before and after-effects of the extensive 2016-7 Wylye Stockton restoration on the trout and grayling populations. This has been planned with the GWCT and funded by them alongside the GRT and the Grayling Society.

This study will explore whether the cost of site restorations has benefitted fish populations – a topic that has rarely been studied in the chalk stream environment, and which will complement the studies being carried out on the Anton.

Further reading

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Huml, J. V., W. E. Harris, M. I. Taylor, R. Sen, C. Prudhomme, J. S. Ellis and Z. Zhang (2020). “Pollution control can help mitigate future climate change impact on European grayling in the UK.” *Diversity and Distributions* 26(4): 517–532.

Marsh, J. E., R. J. Cove, J. R. Britton, R. G. Wellard, T. Basic and S. D. Gregory (2022). “Density-dependence and environmental variability have stage-specific influences on European grayling growth.” *Oecologia* 199(1): 103–117.

Marsh, J. E., R. J. Cove, J. R. Britton, R. G. Wellard, A. House and S. D. Gregory (2021). “Medium-term environmental changes influence age-specific survival estimates in a salmonid population.” *Freshwater Biology* 66(8): 1530–1545.

Cove, R. J., R. J. Taylor and R. Gardiner (2018). *European Grayling Conservation, Ecology & Management*. Printcentre Wales, Grayling Research Trust.

The Anton restoration project

This is our most ambitious restoration project, begun in 2021.

It is part of the restoration of the whole catchment from the river's source, through Andover, to the junction with the Test. This Catchment Based Approach (CaBA) is expected to optimise river restoration outcomes.

The results of our restoration are being evaluated in research supervised by the University of Southampton and part-funded by the Society and Southern Water. The aims include quantifying the following:

- the effect(s) of introduced large woody debris on overall biodiversity, the beneficial effects of which are well established in freestone streams, but not for chalk streams
- the response of trout and grayling populations to the restoration
- the rate of colonisation of the new river channel by both fish and macroinvertebrates (eg river flies and Gammarus)
- the effect(s) of increasing habitat heterogeneity on overall biodiversity.

The electrofishing component of these studies is being used to evaluate the effects on all fish populations. We are currently sampling seven sites annually in the autumn: Westover Beat 6, Westfair Beat 7 (one site) Westfair Beat 8 (two sites – top and middle), Beat 5 (two sites – upper and lower) Fullerton Beat 1 (control site).

The results of this three-year PhD study are expected later in 2026.

Such studies are required to support investment in future chalk stream restoration projects and have attracted a lot of interest from freshwater ecologists. The importance of this field of research to the wider community is borne out by the funding of two further PhD studies on the next phases of our Anton restoration, at no cost to the Society, by Southern Water.

Background

The development of electrofishing for research

The first patent proposing this technique was granted to Isham Baggs of Islington, London in October 1863, but the patent was unfulfilled because batteries capable of providing adequate energy for this were not available at the time.

International researchers in the late 19th Century described the orientation and movement of fish towards anodes and the physiological and environmental factors affecting this. However, it was not until the late 1920's in the USA that electricity was first used in fishery management as an electrical screen to restrict the movement of salmonids into artificial drainage and irrigation channels.

Since then, in addition to its use for directing fish movement, it has been developed for the eradication of invasive species, and to reduce the abundance of native species (as it was by the Society in the 1960s). This review has concentrated on the other major use of electrofishing: the assessment of fish populations as a research tool in fisheries management, and draws heavily on Bill Beaumont's authoritative book on the topic.

Further reading

Reynolds, J. B. and J. C. Dean (2020). "Development of Electrofishing for Fisheries Management." *Fisheries* 45(5): 229–237.

Beaumont, W. R. C. (2016). *Electricity in fish research and management : theory and practice*. Chichester, West Sussex, UK ;, John Wiley & Sons, Ltd.

State-of-the-art electrofishing in the mid-20th century

Potential hazards

Injury and mortality from electrofishing population sampling

Electrofishing as a research tool has been widely used for the assessment of economically important salmonid populations. In the 1950s and 60s the techniques then used were found to damage trout, the most common injuries being ‘burn’ or ‘brand’ marks. These can be caused by melanophore discharge resulting from too close contact with (but not necessarily touching) the electrode and can be indicative of underlying spinal nerve damage.

Salmonid species are very susceptible to electroshock spinal injury. likely due to their relatively more powerful back muscles which severely contract when inappropriately shocked. This muscular contraction, in conjunction with their small and flexible spinal vertebrae, can cause spinal column damage and haemorrhages. Substantial research in the 1980s and 90s led to the identification of the parameters causing injury, including:

- Alternating current (AC) being used instead of Direct Current (DC) or pulsed DC
- Higher frequencies of pulsed DC
- Higher power than the minimum required. This power is affected by environmental factors including water conductivity, fish conductivity, streambed conductivity and topography, water temperature and clarity, width and depth, amongst others.

Fish stress has been measured, most commonly by measuring changes in blood lactate levels. Fish handling, however, may be more stressful than the appropriately performed electroshock.

Fish movement Short-term upstream movement after electrofishing, handling and release, has been observed in brown trout up to three days post-survey, with larger individuals more likely to be displaced.

Fish mortality with electrofishing catch-and-release by comparison with angler catch-and-release

The results of this earlier research have led us to implement electrofishing and handling techniques that, with trained and experienced operators, minimise the risks of mortality and long-term behavioural changes.

Current post capture mortality, including the temporary storage and handling of fish for measurement (with or without tagging), is less than 2% for the 10,000 salmon parr captured annually for a GWCT research project. Our own findings, from 29 years of grayling population sampling on the Piscatorial Society Wylye waters have a mortality of 38 of the 12,977 grayling captured (0.29% overall with a range of 0-1.7% per year); longer term mortality and/or behavioural effects are likely to be small judging by the frequent recapture of tagged individuals in subsequent study years.

These mortality rates compare favourably with what has been reported in studies on mortality from angler catch and release for brown trout at about 8% (± 4%) and higher than this for rainbows.

There has been growing interest amongst anglers in best practice catch-and-release which has led to “Keep Fish Wet” best practice, a movement that started in the USA in 2013. Their website is referenced by the Wild Trout Trust who have webpages on best practice for catch-and-release. Keep Fish Wet does not seem to have been taken up by the UK angling organisations focused on catching species other than salmonids. However, although Keep Fish Wet is based on fish stress research, there are currently no studies we can find on the probable benefits for fish mortality with strict use of this practice. The fact that we don't often see dead or damaged fish may be related to the increased predation of dead or dying fish as opposed to the result of our current catch and release practices.

Operator safety and equipment

Operators are exposed to lethal electrical currents in and out of water. Equipment was "homemade" until the 1960s when equipment first became commercially available. It was not until 2003 that European standards for electrofishing were published including health and safety aspects for operators.

The Environment Agency now has standards for the construction and safety of equipment and its use. These standards have improved safety for what was a hazardous occupation in the recent past and remains dangerous unless handling guidelines are followed. The dangers result from several factors: pulsed DC is used at a level and frequency that can cause cardiac or respiratory arrest and asphyxia.

The most dangerous situation is from an active electrode touching someone when out of the water - shocks from contact with water near active electrodes are less severe. Added to these risks are those associated with the difficulties of hard and tiring work in fast flowing, often deep, water over an irregular stream bed, whilst managing equipment. These risks are minimised for all the staff involved in our projects by regular electrofishing refresher training.

Further reading:

Nordwall, F. (1999). "Movements of brown trout in a small stream: effects of electrofishing and consequences for population estimates." *North American journal of fisheries Management* 19(2): 462–469.

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Roberts. (2024). "Salmon Monitoring and Fisheries Research Review." *The Game and Wildlife Conservation Trust Salmon and Trout Research Centre*, from https://www.gwct.org.uk/media/1558261/Salmon-Monitoring-Fisheries-Research-Review-2024.pdf.

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Design by Nathalie Jamois at Abricot Production