Fisheries research report 2017

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Front cover: The Bio-Acoustic Fish Fence on the river Frome during the smolt migration. Above: Sampling for invertebrates (see page 12).

Foreword

Welcome to the 2017 GWCT *Fisheries Research Report*. I am delighted to inform you that the fisheries team had a major success in 2017, when their application for EU funding was approved in May. The €7.8m five-year (2017-2022) project is called SAMARCH (SAlmonid MAnagement Round the CHannel) and is part-funded by the EU's Interreg Channel VA Programme. The project involves 10 partners, five from the UK and five from France, who will collaborate towards better management of Atlantic salmon and sea trout in estuaries and coastal waters in the English Channel. The project will enable the team to further develop their research and particularly to learn more about salmonids when they leave our rivers for the sea. As part of the project we welcome Céline Artero to the fisheries team – you can read more about the project's early work on page 20.

Following the very low number of salmon parr encountered during the 2016 tagging campaign, which was mirrored in a number of other rivers around the UK, we waited with baited breath and hoped that this would not be reflected in the numbers of smolts leaving the Frome in 2017. Unfortunately, our fears were realised and the 2017 smolt estimate was the lowest on record with only 4,400 salmon smolts estimated, which is less than half the 10-year average. The juvenile freshwater phase of salmon in the Frome is one year shorter than in most other UK rivers, hence the 2017 Frome smolt output is the first real measure of potential future impact of poor recruitment from the spawning in the winter of 2015/16. This does not bode well for the number of salmon returning to the Frome and other affected rivers over the next two to three years.

Two of the PhD projects part-funded by the GWCT are drawing to a close. Jessica Picken's work on gaining a better understanding of the impacts of low flows on salmonid ecosystems (see page 12) and Robert Needham's work on the effects of beaver dams on trout populations (see page 16). Both topics are currently hotly debated, and we look forward to presenting the results from these studies. Good luck to both in their writing up and submission.

David Mayhew
Chairman of the GWCT Fisheries Research Steering Committee

Céline Artero has joined the fisheries team working on the SAMARCH project (see page 20).
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David Mayhew, Chairman of the Fisheries Research Steering Committee.

1. River Frome salmon population

Electric-fishing for adult sea trout.
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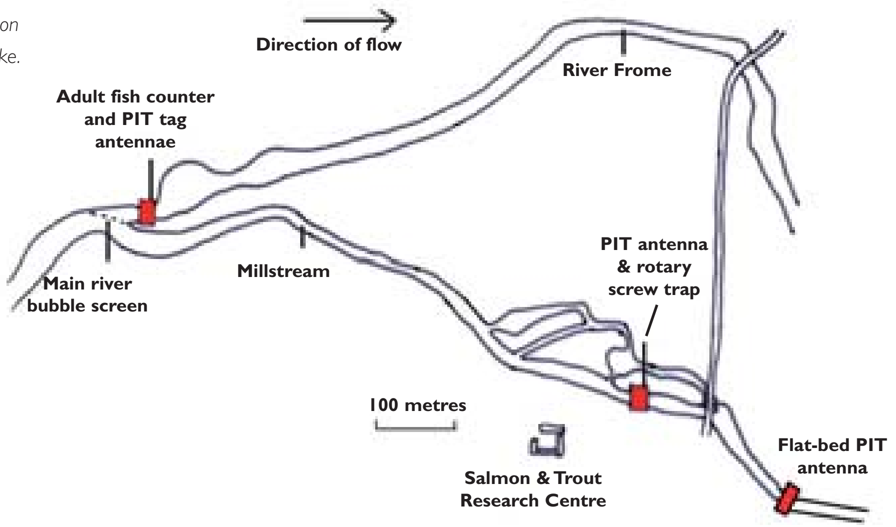
The GWCT fisheries research group is based at East Stoke on the banks of the River Frome in Dorset, and the Atlantic salmon population in the River Frome is at the core of our work. For the past 45 years, the number of adult Atlantic salmon returning to the Frome has been quantified and over the years of studying this population, we have built up an unparalleled monitoring infrastructure at East Stoke and elsewhere in the catchment (see map).

Like most rivers feeding the North Atlantic, the number of returning adult salmon to the Frome showed a marked decline in the early 1990s (see Figure 1). Because this collapse was observed in the majority of rivers across the salmon's distribution, the consensus opinion is that the decline is caused by problems in the marine environment; such as warmer sea temperatures. However, this highlighted the importance of being able to separately analyse the changes affecting survival that occur in freshwater and those that occur at sea. Only by monitoring both smolt output (freshwater production) and returning adults (marine survival) are we able to separately analyse the two components of the salmon life cycle.

Estimating the density of juveniles and the number of emigrating smolts on a catchment scale is very difficult. However, it is possible to estimate population size

Site plan of the counting equipment at the Salmon & Trout Research Centre at East Stoke.



by marking a proportion of the population and then resampling the population later-on and seeing what proportion of the re-captures are marked. At the beginning of the millennium the fisheries group decided to take advantage of developments in Passive Integrated Transponder (PIT) tag technology and use these tags (microchips) to obtain population estimates at different juvenile stages.

Whereas conditions at sea are impacted by global activities, managing the freshwater and coastal environment is much more tangible and optimising the output of smolts from freshwater will help to offset a lower marine survival rate and hopefully boost the population.

Each PIT tag contains a unique code, hence our PIT tag systems not only provide us with population level data, but also life history data of individuals. Utilising PIT tags we can quantify and compare parameters such as growth and survival in different parts of the catchment, as well as changes to these parameters between years. Hence, we can identify environmental drivers of changes within the population. It is exactly such knowledge that can inform us how best to manage the river catchment to optimise the output of smolts.

Adult salmon estimate

We estimate the number of returning adults using a resistivity counter that detects the change in electrical resistance of the water caused by a salmon swimming over the counter. As well as providing population data, the adult counter provides information on migration timing and the environmental factors that influence this. For individuals captured by the video attached to the counter, it also provides estimates of adult fish length, enabling us to look at changes in marine growth over time. In addition, an estimate of the adult return can be made from the PIT tag data obtained from adult fish as they migrate back into the river. The relationship between the freshwater production of smolts and returning adults enables us to quantify the marine survival of separate smolt cohorts. The combination of adult counter and PIT tag data offer a unique opportunity to answer questions about salmon life history that would be difficult to repeat on other rivers.

The run of adult salmon is presented for the period 1 February to 31 January inclusive. Past data and personal observations indicate that most of the upstream movement in January is caused by the continued migration of fish from the previous calendar year migrating to spawn, not fish migrating to spawn in 11 months' time.

Figure 1

The long-term annual data on adult salmon numbers 1973-2017. In the first years of running the counter, downstream migration was not taken into consideration but the estimate number has corrected for this. In years with problems running the counter a minimum number is reported.

The raw data from the fish counter has over the years been collected by the Freshwater Biological Association (FBA), Institute of Freshwater Ecology (IFE) and Centre for Ecology & Hydrology (CEH), but since 2006 has been collected by the GWCT.

	MONTH												
Month	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Total
Gross U/S			11	66	85	83	36	23	191	455	189		1244
Gross D/S			5	8	14	15	4	5	16	50	57		297
Nett U/S	6	11	6	58	71	68	32	18	175	405	132	9	991

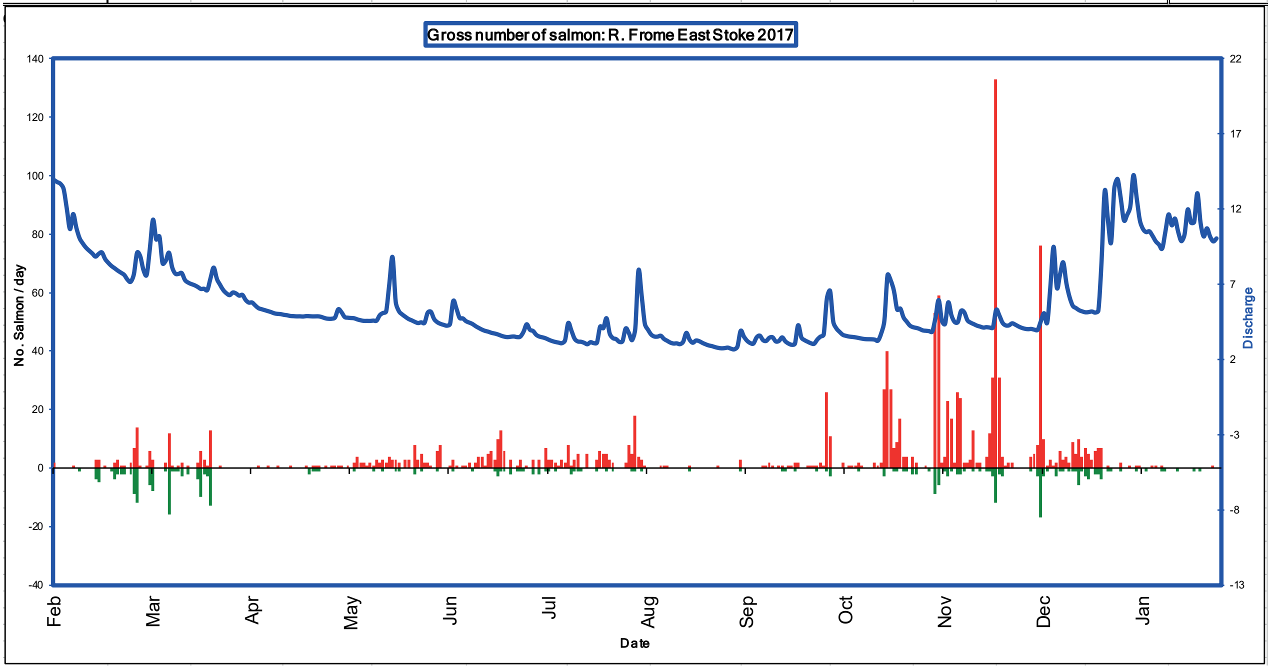


Figure 2
The monthly run data for 2017 and a graph showing daily gross up- and down-stream numbers and river flow. During the months January-March post-spawning salmon oscillate up and down over the counter and only detections that are likely to originate from fresh fish are recorded in nett U/S

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A large part of the effort in running the East Stoke adult counter is focused on verifying and matching the 'counts' from the monitoring equipment. Counts generated by the resistivity counter are identified and verified by a combination of trace waveform analysis and video analysis. In 2017 all the counter's electronics worked well, and we were able to collect verified data (from trace waveforms) for 361 days.

After recording very poor runs of adults in 2013 and 2014, an estimate return of 991 adults in 2017 continued the positive trend seen over the last couple of years with returns in excess of the conservation limit (see Figure 1). This was the result of a good run of one sea-winter fish and a decent run of two sea-winter fish.

In 2017 summer flows were low, but the water level was kept high owing to excellent in-river growth of water crowfoot (*Ranunculus spp.*) backing up the water level. Resulting conditions were favourable for parr habitat and due to the high-water level upstream, migration of adults was unhindered, but even so, the majority of adult upstream movement during the summer occurred during flow events (see Figure 2).

Summer flows were low in 2017 but the water level was kept high owing to excellent in-river growth of Ranunculus.

Smolt estimate

We have estimated the number of smolts emigrating from the river since 1995 but the installation of our first PIT antennae in 2002 marked a milestone in the accuracy of these estimates. This methodology has allowed us to provide a very accurate estimate and to calculate potential variation around this estimate (95% confidence intervals).

During the smolt run we use a device called a Bio-Acoustic Fish Fence (BAFF) to divert the fish into the Mill Stream at East Stoke. The BAFF is a curtain of bubbles that has sound entrained within the bubbles, thereby creating an audio-visual impression of a barrier diverting the fish (see picture). The diversion efficiency of the BAFF is very good, deflecting approximately 80% of the smolts down the Mill Stream (see map on page 4). In the Mill Stream, a proportion of the fish are trapped using a rotary screw trap (RST).

The number of smolts leaving the River Frome in the spring of 2017 was the lowest on record. The smolt run estimate for 2017 was 4,381, which is less than half of the 10-year average (9,689) and two thousand fewer than the second-worst year on record (see Figure 3).

As more than 97% of the Frome smolts are one year old, the poor 2017 smolt run was a result of poor recruitment from the adult fish that spawned in the winter of 2015/16. Low numbers of young salmon were already apparent during our annual parr tagging campaign in the late summer of 2016, for which the catchment population was estimated to be 35,151 – substantially fewer than the 10-year average (91,353 – see Figure 5).

(Above) The RST uses the river current to turn a large drum, which guides the fish into the central tube that funnels them into a holding box. (Below) The curtain of bubbles diverts 80% of smolts down the Mill Stream.

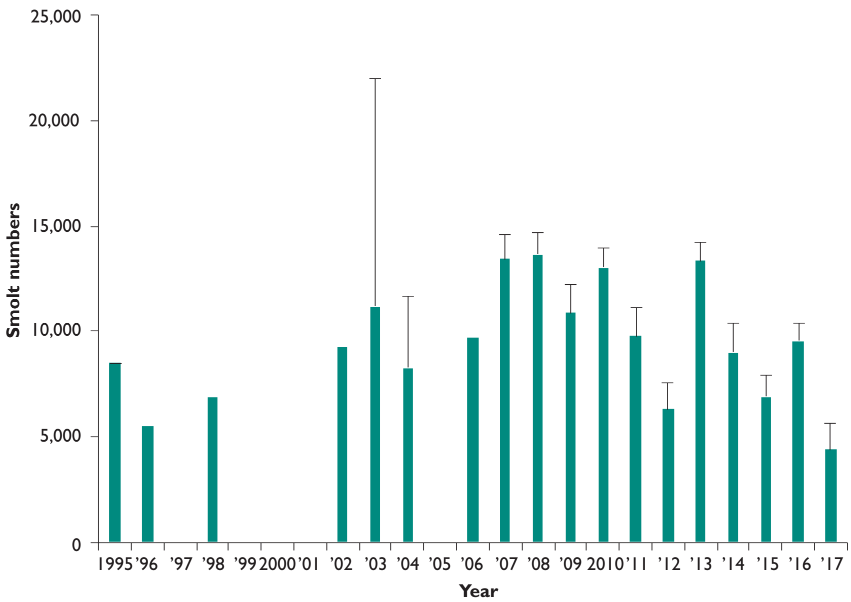
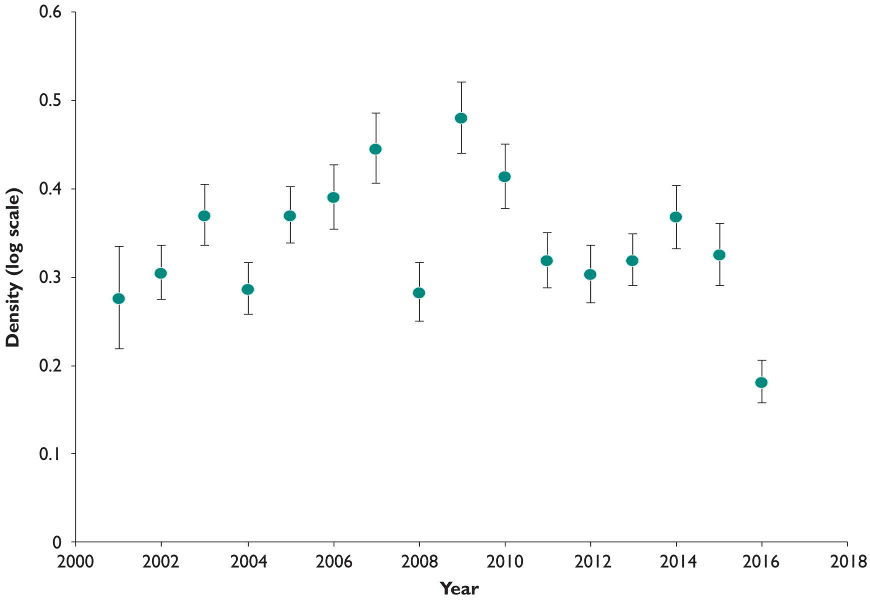


Figure 3

Spring smolt estimate with 95% confidence intervals (1995-2017)

Figure 4

The density of 0+ salmon averaged for all catchments in England where juvenile screening data were considered available. Note y-axis on log scale. (© Environment Agency)



Poor recruitment of salmon from the 2015/16 spawning season was observed in many rivers across England and Wales, suggesting it is a national, rather than a local, phenomenon (see Figure 4).

In 2015 we recorded 822 adults entering the River Frome for the 2015/16 spawning season, which was slightly more than the 10-year average of 746 (see Figure 1). This suggests that the problem affecting recruitment must have occurred sometime between spawning and the late summer of 2016, rather than having fewer than normal spawning fish present in the river.

During the early part of the winter in 2015/16, when the adult salmon were laying their eggs, unseasonably warm weather prevailed. The high air temperature resulted in an average water temperature in the River Frome for December 2015 of 11.2°C. This was the warmest December temperature recorded this millennium, 3.3°C warmer than the average December temperature and 2.0°C warmer than the second warmest in this millennium. We speculate that the high water temperature during spawning and early egg incubation had a negative impact on egg survival and subsequent juvenile recruitment.

Winter river temperatures were warmer in 2015. Our PIT tag antennae record tagged smolts migrating to sea and adults returning to the river.

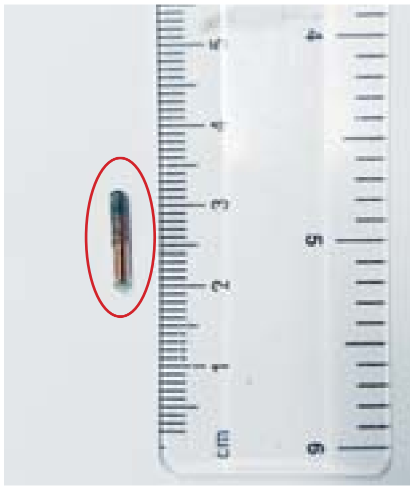
Juvenile estimate

For each of the past 13 years, in September, we have electric-fished and tagged approximately 10,000 juvenile salmon (8-15% of the juvenile salmon population in the catchment) with PIT tags. These small tags (just 12mm long x 2mm in diameter – see picture) are inserted into parr and enable us to individually identify the fish when they swim past our detector antennae. The PIT tag stays with the fish for life and passage of tagged fish out to sea and any fish returning from the sea, are recorded by the tag detecting equipment installed throughout the catchment. During the 2017 tagging campaign we encountered high densities of juveniles (parr) in large parts of the catchment. Indeed, the parr density was the highest encountered during the tagging campaign for a number of years. This made relatively light work of catching and tagging our target 10,000 salmon and 3,000 trout parr. Even so it took three weeks for 14 staff and volunteers each day to tag the target number of parr and to visit all our long-term sites.

The 2017 parr were recruited from a similar number of returning adults as the 2016 parr (see Figure 1). Such contrasting recruitment success again highlights the importance of the freshwater component of the salmon life cycle and its potential to affect stocks in years to come.

The low number of smolts that left the River Frome for their feeding grounds in the North Atlantic in 2017 is likely to result in a marked reduction in the number of adult salmon returning to the river in 2018 and 2019. Furthermore, we expect fewer than average adult returns in other affected rivers throughout the UK, albeit that the effects might be seen in later years depending on the age that their smolts go to sea.

(Above) We electric-fish and tag approximately 10,000 juvenile salmon. (Below) The PIT tags are just 12mm long x 2mm in diameter.



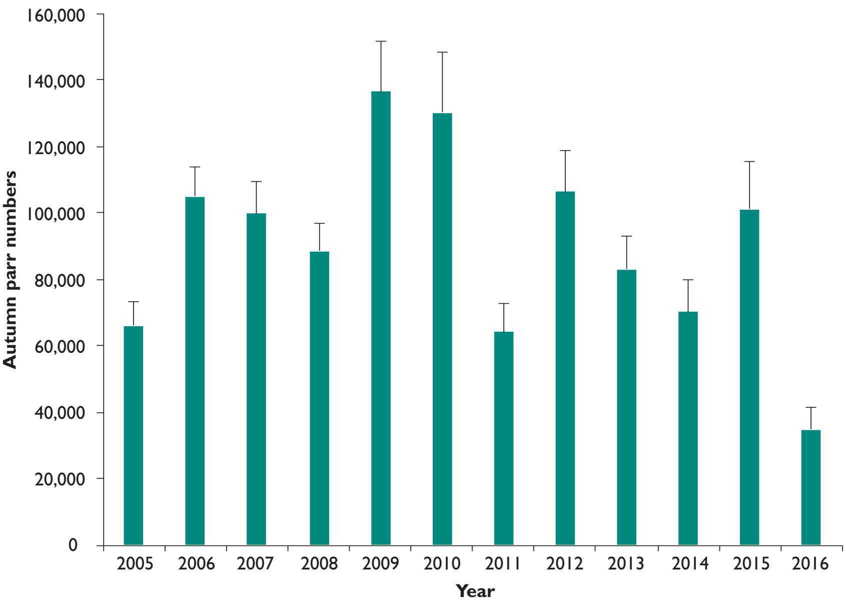


Figure 5

Estimated number of salmon parr in the entire Frome catchment in September (1995-2016)

2. Could bigger salmon smolts be better?

A rotary screw trap is used to capture and measure a sample of emigrating juvenile Atlantic salmon smolts.

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Atlantic salmon stocks (as indicated by catches) are declining (see Figure 6). For a long time, the finger of blame has been pointed at the marine environment, where climate change and the processes it influences, such as water temperature, sea-level and spatial and temporal variation in algal blooms, are thought to have rendered the environment hostile to migrating smolts. More recently, however, there has been a growing sense that factors affecting juveniles during their development, ie. in the freshwater environment, might play a larger role than previously judged.

Since 2006, the fisheries team have been capturing and measuring juvenile Atlantic salmon emigrating to sea, known as smolts. Each year, between 200 and 600 captured smolts are individually identifiable thanks to an electronic tag, known as a Passive Integrated Transponder (PIT) tag, implanted the previous September as part of our research programme. These individuals are detected on our network of PIT antennae when they return to the Frome to spawn as adults. We also measure the length of these tagged smolts.

Among the long-standing but untested theories about smolt survival at sea is that size matters: the shorter/smaller you are, the less likely you are to survive. To date, however, the lack of individual data coupled with the low probability of adult return has prevented us from confronting this theory with hard data. Our smolt data fills that gap.

Using cutting-edge statistical techniques known as multi-state mark-recapture state-space models, we have results suggesting that smolt survival to adulthood, hereafter referred to as the 'probability of adult return', is a function of smolt length (see Figure 7). It seems that the larger you are, the higher your probability to return as an adult. Moreover, the effect is not small: a smolt of approximately 16cm is between two and three times more likely to return as an adult compared with a

Figure 6

Catches of Atlantic salmon have been declining for decades. In part, this reflects reduced fishing effort but the declines are thought to represent declines in stocks, even after successive fishing quota restrictions

ICES Northeast Atlantic Commission countries Northern

ICES Northeast Atlantic Commission countries Southern

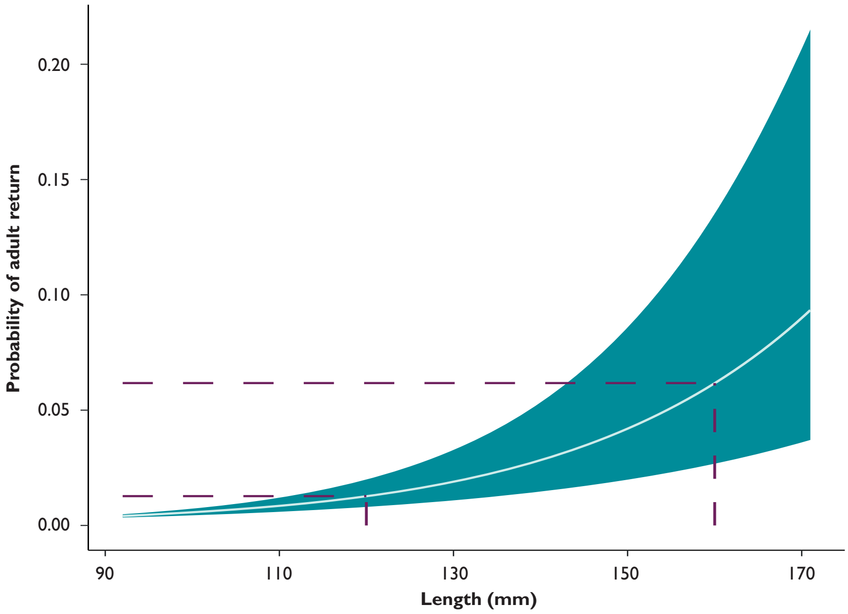


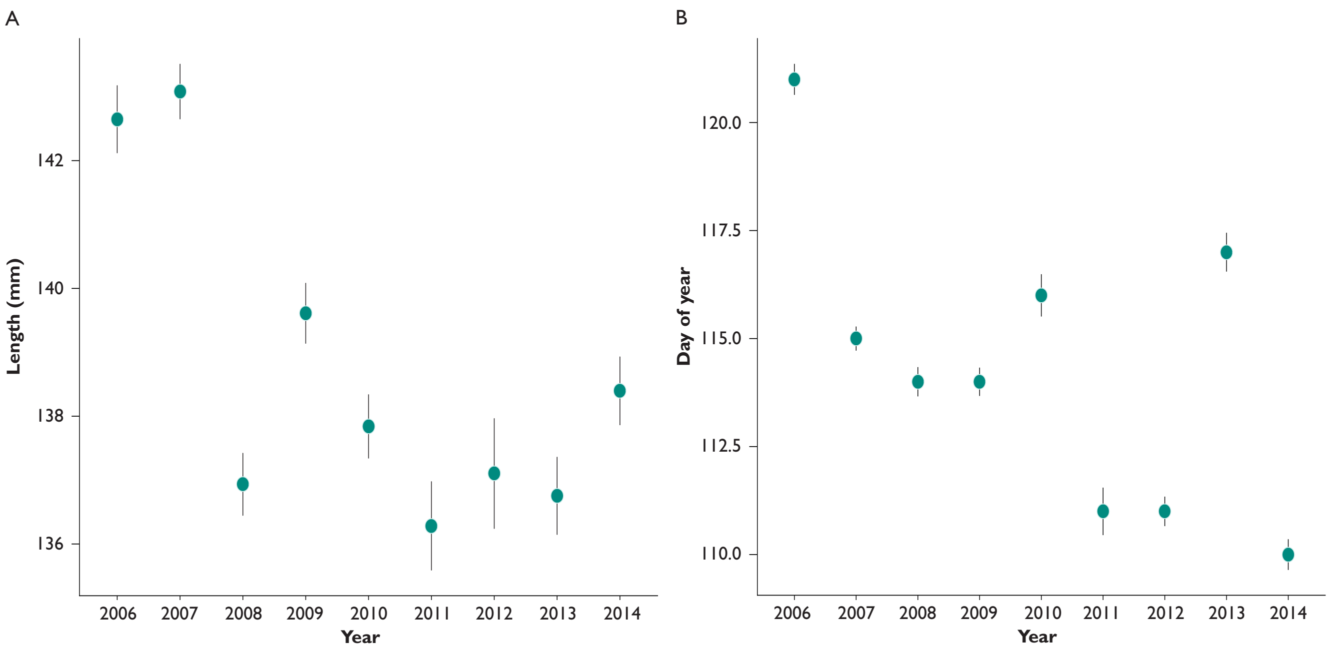
Figure 7
Smolt length has a considerable effect on the probability of the individual returning to its natal river to spawn: among one year old smolts a 16cm smolt is two-three times more likely to return as an adult compared with a 12cm smolt

12cm smolt. To our knowledge, this is the first time that this result has been shown for a wild smolt population while accounting for an imperfect adult detection system.

What does this mean? Taken in isolation, it suggests that juvenile development in the freshwater environment influences the number of returning adult salmon, ie. potential spawners. This is an important finding because it suggests that we could manage the freshwater environment to maximise the quality (ie. length and weight) of emigrating smolts and thereby the numbers of returning adults. This could be particularly important in light of the observation that Frome smolts and possibly smolts elsewhere, appear to be getting shorter (see Figure 8A). However, it is unlikely that their length at emigration is the only factor influencing their probability of adult return: marine conditions are undoubtedly deteriorating and the timing of salmon migrations are changing. For example, the median date of juvenile smolt migration seems to be getting earlier (see Figure 8B).

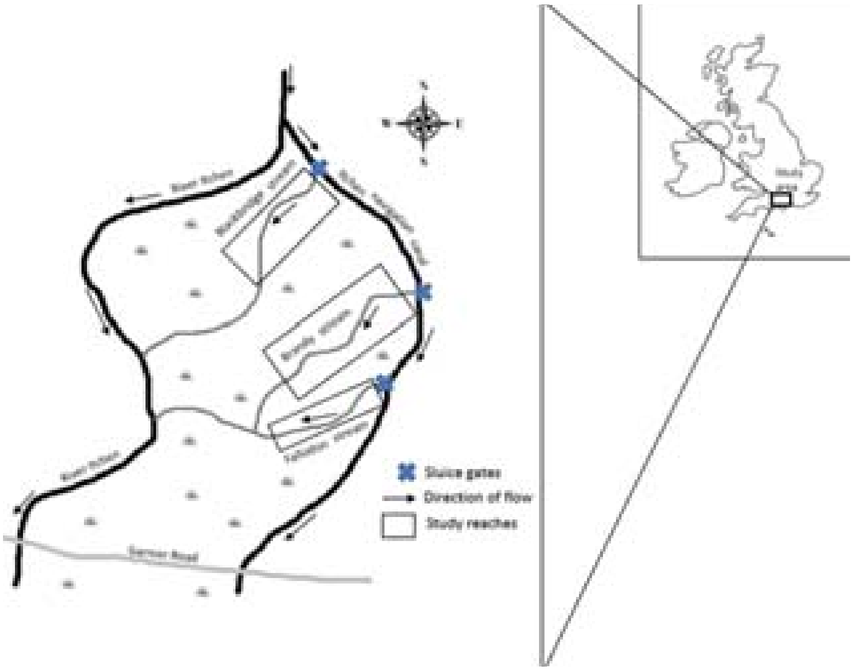
This study is developing quickly. It is a GWCT Fisheries SAMARCH project objective and we have recently appointed a PhD student to further this work. Initial plans are that the PhD study would seek to show similar results for other smolt populations and delve deeper into the possible mechanism(s). We believe it will reveal the importance of the GWCT salmon research programme and provide strong evidence that we can improve salmon stocks by improving our rivers.

Figure 8 A & B
Plots showing (A) that age one smolt length appears to have declined since 2006 but also (B) that the median date of age one smolt migration to sea is becoming earlier. What are the implications of these patterns for smolt survival to adulthood?



3. Low flow and salmonid ecosystems

(Above) A healthy community of aquatic macroinvertebrates in chalk streams is important for salmonid growth rate and condition. (Right) Schematic map of the study site. Study streams have rectangle boxes around them.



Jessica Picken is a PhD student working with the GWCT, Queen Mary University of London, Cefas and Cardiff University, looking at aquatic macroinvertebrates and salmonids in chalk streams to investigate the effects of low flow on these ecosystems.

Jessica using a Surber sampler to sample the macroinvertebrate community.

In chalk streams the frequency and severity of low flow events, particularly in summer, is projected to increase over the next 40 years due to external pressures. Climate change models predict increased summer temperatures and reduction in summer rainfall. Furthermore, population growth in the chalk stream catchments will result in increased abstraction for domestic water use. The combination of these pressures will reduce the water level within the aquifers that feed the rivers and cause a reduction in river flow.

This PhD project aims to gain understanding of the effects of low flow on salmonid ecosystems. A three-year study, completed in 2017, investigated the effect of two different levels of flow reduction and a control (where flow remained unaltered throughout the experimental period) on three streams (see map). Macroinvertebrate samples were taken before, during and after flow manipulation.

Aquatic macroinvertebrates contribute up to 75% of salmonid diet, hence a healthy community of aquatic macroinvertebrates is important for salmonid growth rate and condition. It is wildly accepted that flow reduction can affect the aquatic macroinvertebrate communities within chalk streams. How macroinvertebrate communities change within different streams under the same flow reduction scenarios is, however, poorly understood.

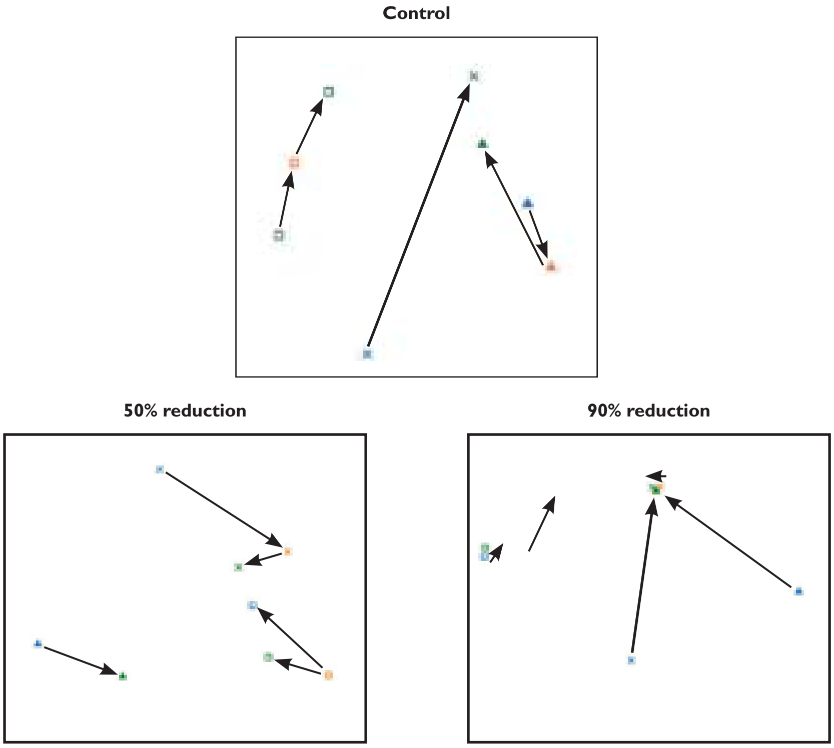


Figure 9

This figure represents macroinvertebrate community change within the three different streams for a given flow treatment. There is no clear pattern that all streams follow for a particular flow treatment, apart from Fallodon and Black bridge stream in the 90% reduction treatment. Different shapes represent the three study streams (Fallodon = cross, Black bridge = triangle, and Brandy = square) and different colours represent the three different sampling occasions (before = blue, during = orange, and after = green). *Arrows show direction of community change between the different occasions. Note: Within the 90% reduction treatment, during and after communities at Black bridge are at the same location.*

The current flow management strategy is 'one fits all' for chalk streams, where it is assumed that all chalk streams will respond in a similar fashion to reduced flow as they have similar underlying characteristics. These characteristics include steady base flows, high water alkalinity and clean gravels of uniform size. However, other characteristics such as water depth, velocity and channel width will vary with each stream and these characteristics have the potential to affect macroinvertebrate community response to flow reduction.

Results from this study indicate that the trajectory of the change within macroinvertebrate communities in response to flow reduction was different in the three streams (see Figure 9). This suggests that individual stream characteristics influence community response. We are currently exploring the drivers underlaying this variation in response to flow reduction as these changes will affect not only the macroinvertebrate community but also, salmonid food availability. If salmonid diet is selective, how does low flow instigated community changes affect their growth rate and condition within streams?

Combining findings for the impact of low flow on physical habitat, basal resources, macroinvertebrates and salmonid behaviour and survival will enable knowledge-based management to safeguard salmonid stocks in southern England's chalk streams.

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(L-R) Before, during and after low flow.

4. The role of *Ranunculus* in chalk streams

Jessica Marsh is a PhD student working with the GWCT and Queen Mary University of London studying the role of *Ranunculus* in lowland salmonid ecosystems. The PhD is funded by the G and K Boyes Trust.

A project looking at the role of *Ranunculus* (water crowfoot) in chalk stream ecosystems has recently completed a novel two-year experiment that will quantify the effect of the aquatic plant on the river habitat and its flora and fauna, focusing on juvenile Atlantic salmon and brown trout and their aquatic invertebrate prey.

In March 2016, we manipulated *Ranunculus* cover at nine sites on the North Stream of the river Frome, Dorset, so that we achieved three 'low' (less than 10%), three 'medium' (30-40%) and three 'high' (greater than 60%) cover sites. Treatments were achieved by removing existing plants from the 'low' sites and planting into the 'medium' and 'high' sites, as required, burying roots of plant bunches with a shallow layer of river bed sediment. The planting was very successful but the low treatment required removal throughout the year to maintain the desired experimental *Ranunculus* cover, until autumn when the plants naturally die back.

Prior to the manipulation, and every six weeks thereafter, we collected data from the nine sites. At each site, we recorded water depth, water velocity, percentage plant cover, plant species and sediment composition at 25 locations. These data allow us to understand how different amounts of *Ranunculus* can influence the river habitat, and whether it creates preferable habitat for juvenile fish. Aquatic invertebrates were sampled at five of the 25 locations to quantify the abundance and diversity of invertebrates within each site. During the months of June and October, we also electric-fished juvenile Atlantic salmon and brown trout. As well as recording the density of juvenile fish, we recorded the length and weight of individuals and inserted a Passive Integrated Transponder (PIT) tag so that we could identify them and measure their growth rates when we recaptured the fish on later sampling occasions. We also collected gut contents by flushing the stomachs of the fish, so that we could assess any differences in diet in these differing *Ranunculus* covers. Fieldwork for this project finished last December and sample processing and data analysis is ongoing. An initial look at the data available for June and August shows that we successfully manipulated the three *Ranunculus* treatment levels (see Figure 10A). We found a high abundance of aquatic invertebrates in the 'high' *Ranunculus* treatments and the lowest abundance in the 'low' treatments, though the effect is more pronounced in June (see Figure 10B). Although *Ranunculus* appears to influence the invertebrate abundance in these two months, this relationship may change with time of year and we will need to process the fish stomach contents to assess whether the fish are utilising the prey resources differently in different treatments.

Existing Ranunculus *was removed from our low cover sites by digging up the roots of the plant beds.*

Bunches of the removed Ranunculus *were planted into natural patches within the high and medium treatments, by burying the roots with a thin layer of bed sediment.*

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(Right) Setting up stop nets before electric-fishing for juvenile salmon and trout.

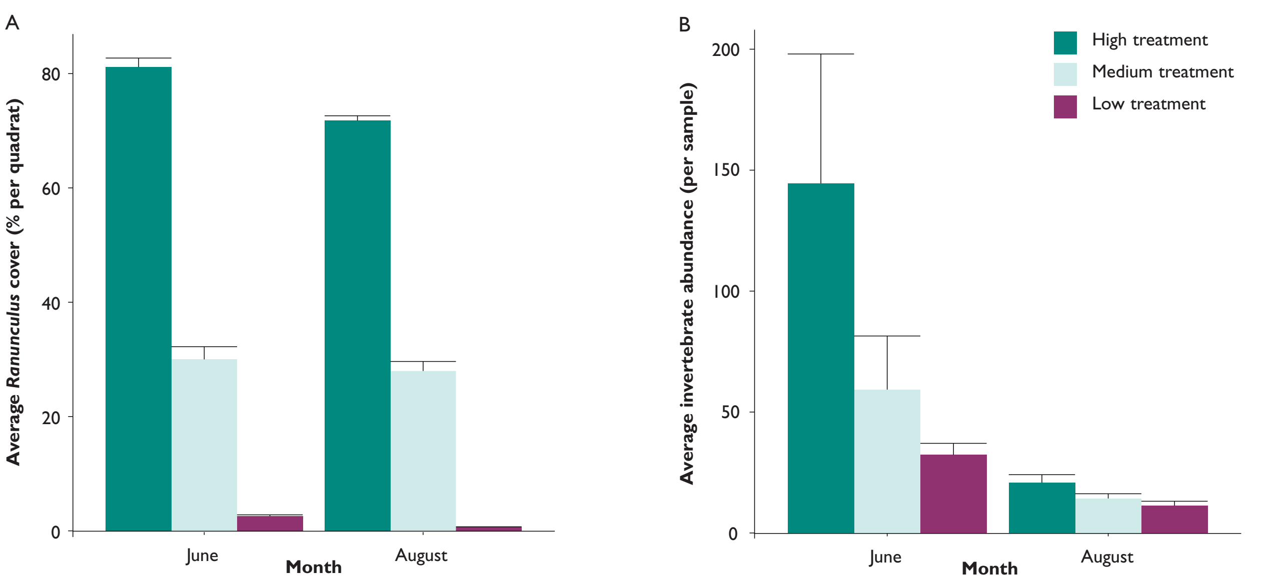
It will be exciting to uncover how the treatments affect both the number (density) and quality (body condition and growth rates) of the fish, and understand how this relationship is being driven: either directly through *Ranunculus* or indirectly through prey source or habitat creation caused by the presence of *Ranunculus*. Gaining an understanding of its role could highlight its potential as a management tool to conserve our juvenile Atlantic salmon and brown trout, and the populations as a whole.

Thank you to Dave Cooling for all his hard work and good company in the lab helping to process the aquatic invertebrate samples.

Jessica Marsh surveying the Ranunculus *cover in a 'high' treatment site in summer, after successful planting.*

Figure 10 A & B

Average *Ranunculus* cover (A) and average aquatic insect abundance (B) across the treatments during June and August



5. How do beaver dams influence brown trout?

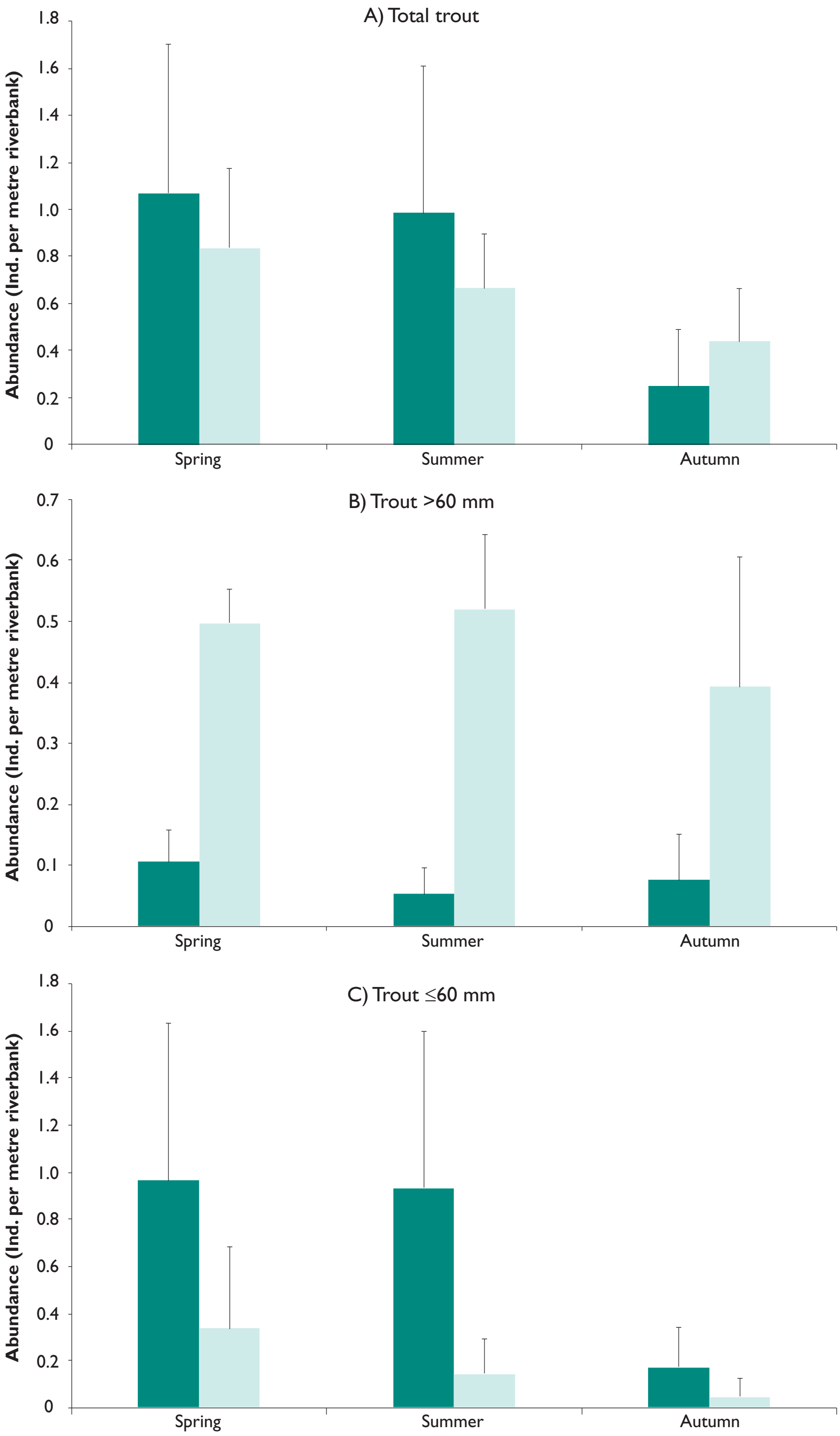
Populations of re-introduced and escaped Eurasian beaver *(Castor fiber)* currently exist in England and as of November 2016, beavers have been given native species status in Scotland. Beaver activity can significantly modify riverine habitats and are often referred to as 'ecosystem engineers'. Beavers activity has been shown to benefit other wildlife groups, increasing species richness and diversity. However, fishery bodies are concerned that the return of beavers may negatively impact already threatened salmonid populations through their damming activities.

PhD researcher Robert Needham has been gathering data in northern Scotland for three years, using electric-fishing and PIT tag technology to quantify the impact of beaver activities on a population of brown trout. The experimental system

Figure 11 A, B, C

Mean brown trout abundance measured as trout per river metre during spring, summer and autumn 2016 in the beaver treatment and the control. Graph A) Total abundance of trout. B) Abundance of trout >60mm and C) Abundance of trout ≤60. Error bars denote 95% confidence intervals

Control
Beaver



Rob Needham is a PhD student working with the GWCT and Southampton University studying the effects of beaver activity on trout migration and population dynamics.

consists of two tributaries that feed a common loch. Beavers have modified one of these tributaries, having constructed five dams and subsequently, creating three bypass channels, while the other tributary has had no beaver activity. PIT telemetry was used to assess the ability of brown trout to pass a series of beaver dams when migrating up- and down-stream (see *GWCT Fisheries Research Report 2016*). In addition to the dams themselves, the resulting habitat modifications will change prey and habitat availability for salmonids, which is likely to impact abundance and size distribution of the trout population.

The beaver modified stream had a higher density of older trout.

Abundance (trout per river metre)

A total of 2,172 brown trout were captured and processed between October 2014 and December 2016 between the two tributaries. There was no statistical difference in the total abundance of trout between the beaver and the control stream (see Figure 11A). However, the size distribution in the two streams were very different (see Figure 12). The control stream had a higher density of young of the year trout (≤60 mm) whereas the beaver modified stream had a higher density of older trout (>60 mm) (see Figure 11B and C).

Preliminary analysis provides evidence of spawning in both tributaries, confirmed by an influx in the abundance of ≦25 mm trout (see Figure 11 and 12) during the spring. Indeed, additional studies at the site using PIT telemetry support this and show that trout do pass beaver dams given suitable conditions (see *GWCT Fisheries Research Report 2016*). However, there is some evidence that survival of the young of the year was reduced in the beaver impacted stream (lower number of 25-50mm long trout). The beaver modified stream did, however, support a higher number of older trout (see Figure 11B).

Much has been said in the media about beaver impacts – negative and positive – and the GWCT looks forward to following this project to its conclusion as it will provide evidence to ensure that knowledge-based management strategies are developed for this new hotly-debated conservation issue.

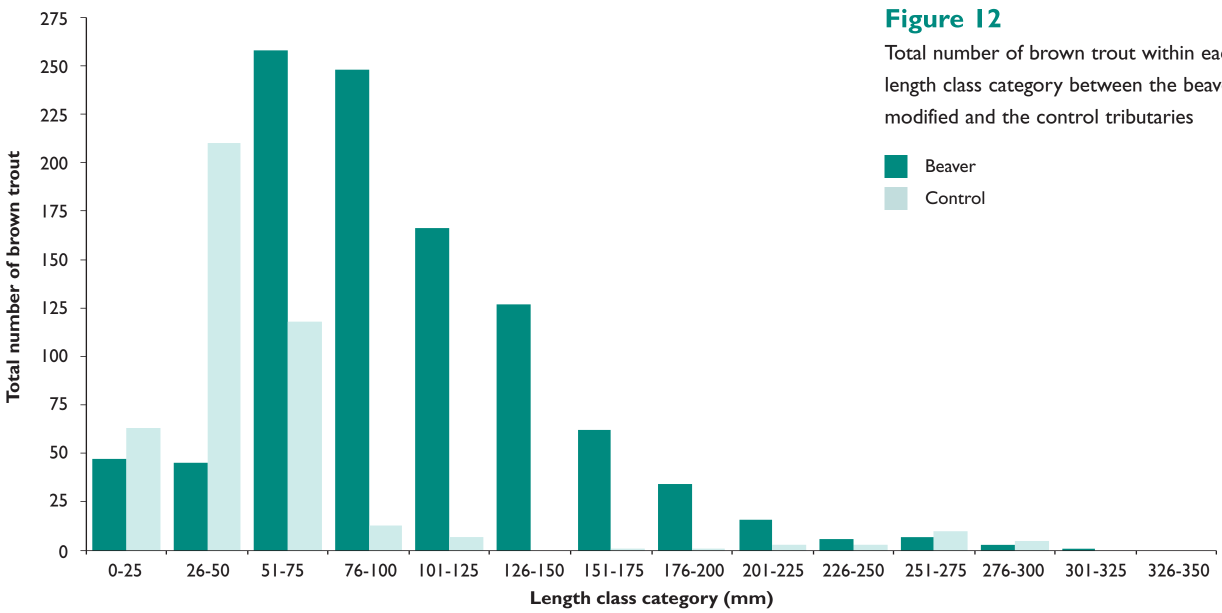


Figure 12

Total number of brown trout within each length class category between the beaver modified and the control tributaries

Beaver

Control

6. Grayling on an English chalk stream

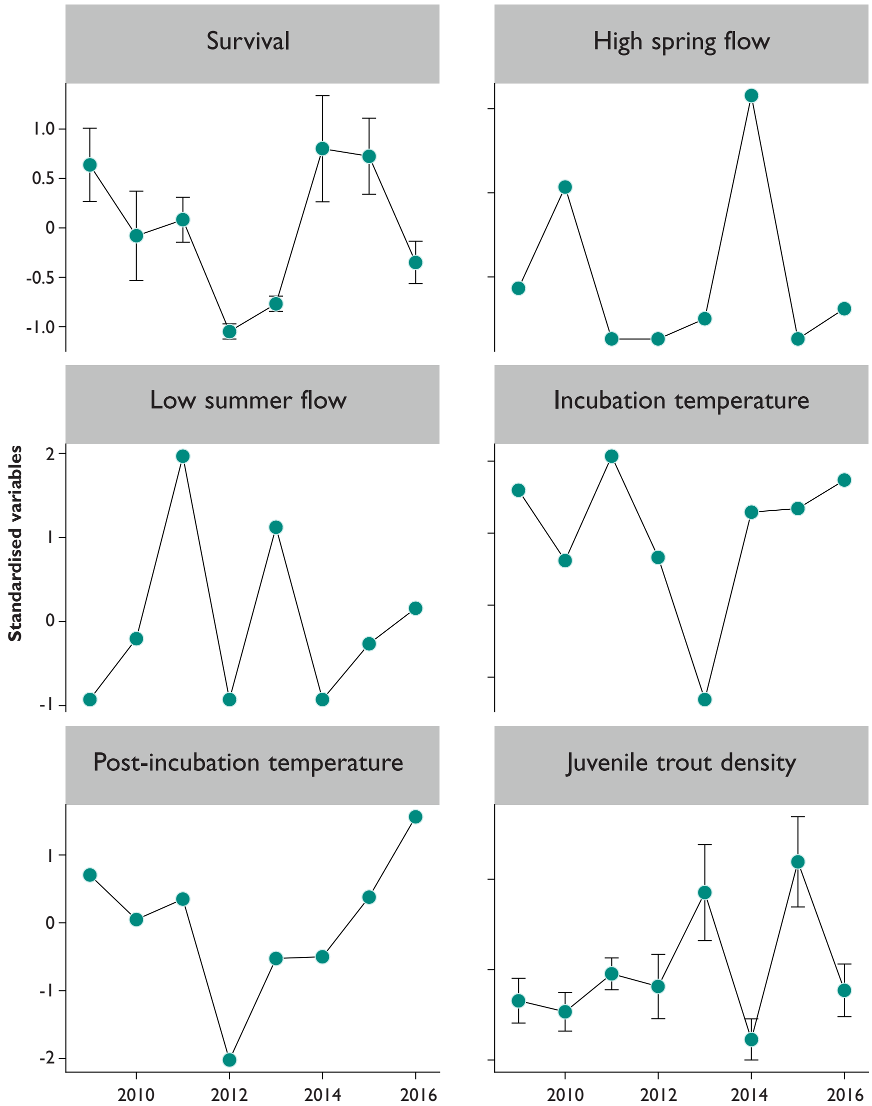
Tea Basic was employed by the GWCT on a short-term contract funded by the Grayling Research Trust to undertake this study under the supervision of GWCT and Bournemouth University. The study has been accepted for publication in *Ecology of Freshwater Fish*.

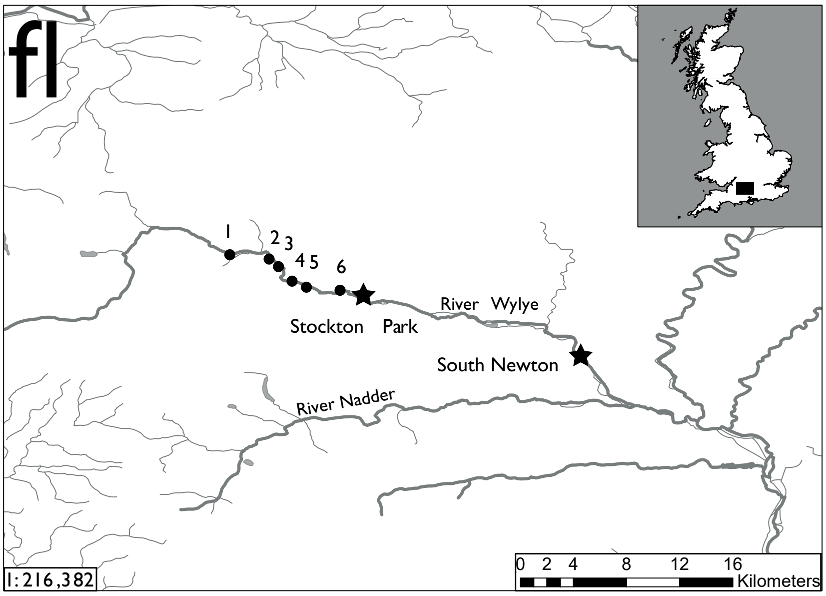
For this study, we used eight years of 0+ grayling density data collected at six sites on the river Wylye, Wiltshire, between 2009 and 2016 by the Piscatorial Society, GWCT and Natural Resources Wales. Discharge and temperature data were extracted from the nearby gauging stations and 0+ brown trout densities were collected during grayling surveys. We explored the influence of these factors on grayling recruitment in a set of statistical models. The analysis showed that elevated discharge during incubation did not affect grayling recruitment, while an increase in the number of days with low flow post-incubation was detrimental for their survival (see Figure 13). Furthermore, both incubation and post-incubation temperatures were important determinants of grayling survival. Although, incubation temperature anomaly was positively related to grayling survival, post-incubation temperature anomaly and 0+ grayling survival had a more complex relationship, with survival increasing up to 13.5°C beyond which it had a negative effect (see Figure 14). Surprisingly, 0+ grayling survival increased with 0+ brown trout densities, indicating that underlying processes regulating both populations might be similar.

These outcomes emphasise the importance of sensitive salmonid-river management of natural flows and riparian areas to maintain and/or restore conditions to provide minimal flow requirements for salmonids, while limiting temperature increases. This will be particularly important for southern English

Figure 13

Line plots showing mean values (and standard errors) of grayling survival between 2009 and 2016 (top-left panel) and similar plots for the explanatory variables used in the statistical models to describe changes in grayling survival





Map showing the location of the six investigated sites on the river Wylye indicated by black dots (Ordnance survey, 2015). Stars indicate locations of discharge (Stockton Park) and temperature (South Newton) gauge stations.

streams in the future due to climate change scenarios predicting lower precipitation and higher air temperatures, which could negatively affect rivers and adjacent riparian flora and fauna. Future work using the Wylye Grayling Study data should include exploring the impacts of these variables on grayling growth in the southern chalk streams, but also investigating recruitment and growth drivers of grayling in less stable, rain-fed systems.

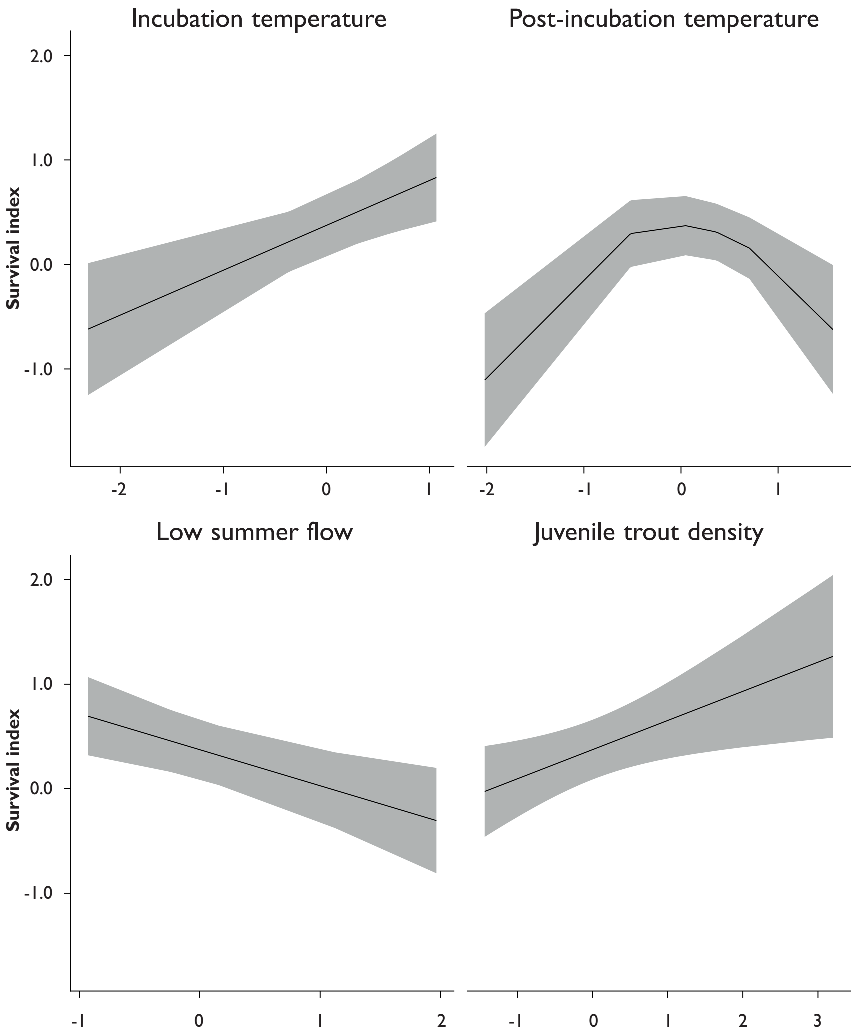


Figure 14
Line plots showing effects of explanatory variables on grayling 0+ survival

7. Tracking salmonids at sea

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Both sea trout and Atlantic salmon have a complex life cycle utilising both fresh and marine waters. Whereas the freshwater phase of their life cycle is relatively well understood, very limited knowledge exists on the migration patterns and habitat use of these species in transitional and marine waters. The SAMARCH project, undertaken by the GWCT and its partners, aim to improve the understanding of marine migration and behaviour of the sea trout and Atlantic salmon.

The project, co-funded by the European Union Interreg Channel programme, takes place in four estuaries, the Frome and the Tamar in the UK and the Bresle and the Scorff in France (see map below).

Location of the four estuaries used in the SAMARCH tracking project.

The acoustic receivers are programmed and then placed in the lower rivers and estuaries.

Location of acoustic receivers (green dots) to track salmonid migration in the Tamar estuary.

(Above) An acoustic transmitter which emits a ping every 30 seconds that will be picked up by the receivers. (Below) The data storage tag will be inserted into the fish and will record temperature and depth every two minutes.

Sea trout kelts as well as sea trout and Atlantic salmon smolts will be captured and tagged with acoustic transmitters to obtain information on their migration behaviour.

The acoustic transmitters emit a ping every 30 seconds that will be recorded by acoustic receivers located in the lower river and throughout the estuary when tagged fish pass the receivers (see an example of receiver deployment design in the Tamar estuary – see map above).

Data from the acoustic tags will provide information on timing and duration of the seaward migration of smolts and kelts out of the four estuaries. Furthermore, the acoustic tags will also inform us about the use of different areas of the estuaries and the timing and migration pattern of the sea trout kelts return migration for repeat spawning.

In addition to the acoustic tag, sea trout kelts will also have a data storage tag implanted. The data storage tag will record temperature and depth every two minutes. These parameters will be used in combination with observation of sea surface temperature, sea bed topography and tide to reconstruct the most likely migration route of the fish while at sea.

Whereas the data from the acoustic tags will be recorded and stored by the acoustic receivers, we need to recover the data storage tags to get the recorded data; there is a reward for returning these tags (see page 23).

The combination of the two tags will provide information on swimming depth, habitat use, and duration of the migration of sea trout in transitional waters. Similar

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The first sea trout kelts were tagged in late 2017.
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Each smolt will be tagged with an acoustic transmitter (above).

techniques have successfully been used to track sea bass migration, but no previous study has provided this detailed an insight into the marine behaviour of sea trout.

This project started late 2017 with the deployment of acoustic receivers and the first sea trout kelts were tagged in rivers Tamar, Frome and Bresle. Tagging of smolts will begin in spring 2018.

The knowledge gained from this tracking project will not just improve our understanding of salmonid migration and habitat use while at sea, it will also enable knowledge-based management of activities such as fishing and dredging in marine areas important to sea trout, to reduce unintended disturbance and exploitation. This will ultimately improve the survival rate of sea trout and Atlantic salmon in the transitional waters, increasing the number of adult returners and helping the recovery of populations in rivers.

Fisheries research acknowledgements

The GWCT would like to acknowledge the financial support for all of the fisheries projects from the Environment Agency, Cefas, Defra, EU Interreg Channel Programme, David Mayhew, Jock Miller, Anthony Daniell and Winton Capital, G & K Boyes Trust, The Alice Ellen Cooper Dean Charitable Trust, The Valentine Charitable Trust, Lord Iliffe Family Charitable Trust, The de Laszlo Foundation, The Balmain Environment Conservation Trust, The HDH Wills 1965 Charitable Trust, The Orvis Company Inc, The Atlantic Salmon Trust, Queen Mary University of London, University of Southampton and Cardiff University.

We would also like to thank the Freshwater Biological Association for renting us facilities and all the riparian owners along the River Frome and other areas for access to the rivers. Without their permission our work would not be possible.

£50 REWARD

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AND/OR A BLUE TATTOO

THERE IS AN ELECTRONIC TAG INSIDE

Electronic tag inside fish

PLEASE KEEP THE WHOLE FISH AND CONTACT

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Phone : 01929 401 896 / 07525 913 086

Site internet : www.samarch.org/project-information/fish-tracking/

WITH DATE AND LOCATION OF THE RECOVERY

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Editing, design and layout: Louise Shervington
Printed on FSC accredited, chlorine-free paper from sustainable forests