Fisheries research review 2018

Edited by Rasmus Lauridsen

Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

Game & Wildlife CONSERVATION TRUST

www.gwct.org.uk/fisheriesreport

CONTENTS

Fisheries Research Review 2018

CONTACT

GWCT's Salmon & Trout Research Centre, East Stoke, Wareham, Dorset, BH20 6BB
T: 01929 401894
E: fisheries@gwct.org.uk

Game & Wildlife CONSERVATION TRUST

CONTENTS

	Foreword	3
1.	River Frome salmon population	4
	A) Adult salmon estimate	6
	B) Estimate of juvenile salmon	7
	C) Smolt estimate	8
2.	Salmon and sea trout at sea	9
	A) Which are the fastest fish?	
	B) Sea trout in the marine environment	10
3.	Does capturing and tagging wild salmon smolts affect their survival at sea?	12
4.	Impacts of reduced discharge on salmonid ecosystems	14
5.	Juvenile salmonid densities and habitat	16
6.	Atlantic salmon return rate and smolt length	18
7.	Overwinter growth of juvenile salmon	20
8.	Scientific publications	22
9.	Reward for tagged sea trout	23

THE FISHERIES TEAM WHO CONTRIBUTED TO THE WORK IN THIS REVIEW

C Artero, WA Beaumont, WRC Beaumont, S Gregory, R Lauridsen, T Lecointre, J Marsh, J Picken, D Roberts, L Scott and O Simmons

Acknowledgements

The GWCT would like to acknowledge the financial support for all of the fisheries projects from the Environment Agency, Natural England, 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, The Piscatorial Society, Natural Resources Wales, Grayling Society, Grayling Research Trust, Queen Mary University of London, University of Southampton, Bournemouth University 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.

Foreword

2018 was a year of mixed emotions for the fisheries team. The poor salmon parr abundance and subsequent 20-year low smolt estimate recorded in the River Frome in summer 2016 and spring 2017, resulted as predicted in a poor return of grilse in 2018 (see page 5). It is encouraging that our work on the River Frome enables us to predict if the run of salmon is likely to be weak or strong, nevertheless it was disappointing to see so few adult salmon returning in 2018. The poor recruitment of juvenile salmon in 2016 was widely observed, particularly in the south-west of England and Wales, indicating that widespread issues were at play. We are currently working with the Water Research Centre and Natural Resources Wales to further our understanding of why recruitment in 2016 was so poor.

I am thrilled to report that our pilot study, tagging adult sea trout as part of the SAMARCH project, was a huge success. This work will provide real evidence of their behaviour and habitat use at sea. Exactly such knowledge is urgently needed to protect this enigmatic species from bycatch in coastal nets and to preserve coastal areas of special importance to sea trout. In the winter of 2017, the team caught and tagged 16 sea trout kelts (post-spawning individuals) between the Rivers Frome, Bresle and Tamar. We have recovered four of the deployed data storage tags which record water temperature and pressure (see page 11). To obtain the data from the tags we must recapture the sea trout or find the tag if the fish dies, which is no mean feat. Given this success, a further 99 adult sea trout were tagged in the winter of 2018. The data obtained from the pilot year has already been used by our SAMARCH project partners, the Environment Agency, in its negotiation with the Inshore Fisheries Conservation Authorities to advocate for stronger regulations on coastal netting to protect our migratory salmonids.

> “knowledge is urgently needed to protect this enigmatic species from bycatch in coastal nets and to preserve areas of special importance to sea trout”

The team have gained well deserved recognition for their hard work. Dr Rasmus Lauridsen now sits on the prestigious International Council for the Exploration of the Sea (ICES) working group for trout (WGTRUTTA) and Dr Stephen Gregory sits on the equivalent ICES group for salmon called WGNAS. The team are also working closely with National Resources Wales and the Environment Agency to shape future salmon management in the UK.

In 2018, we welcomed Olivia Simmons our latest PhD student to the team. She will work in partnership with Bournemouth University on the SAMARCH project to investigate factors affecting changes in juvenile salmon body length with implications for post-smolt survival (see page 20).

I hope you enjoy reading the 2018 *Fisheries Research Review* and appreciate the quality, range and depth of the work undertaken at our Salmon & Trout Research Centre. The amount of work that goes into the pages overleaf should not be underestimated and I would like to thank each member of the fisheries team for their contribution. Tight lines for 2019.

David Mayhew
Chairman of the GWCT Fisheries Research Steering Committee

David Mayhew
CHAIRMAN OF THE GWCT FISHERIES RESEARCH STEERING COMMITTEE

1. River Frome salmon population

Electric fishing for sea trout kelts in the lower River Frome. © GWCT

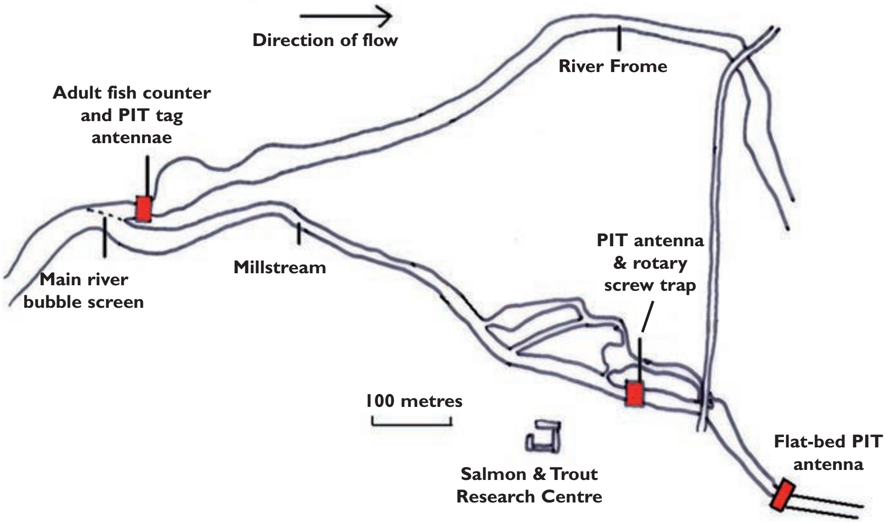
Game & Wildlife CONSERVATION TRUST

Cefas

Environment Agency

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 nearly 50 years, the number of adult 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 many rivers feeding the North Atlantic, the number of returning adult salmon to the River Frome showed a marked decline in the early 1990s (see Figure 1). Because this collapse was observed in 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



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

10,000

juvenile salmon are caught and tagged with a PIT tag, enabling us to follow their future journeys

of juveniles and the number of emigrating smolts on a catchment scale is very difficult. However, it is possible to estimate population size by marking a proportion of the population and then resampling the population later on and seeing what proportion of the individuals captured on the second sampling were 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 the catchment level for juveniles, smolts and returning adults. Whereas conditions at sea are impacted by global activities, managing the freshwater and coastal environment is much more tangible and optimising the number of and the quality of smolts output 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. Using PIT tags we can quantify and compare parameters such as growth and survival in different parts of the catchment, as well as impact of the freshwater phase on their probability of marine survival (see page 18, smolt length). 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.

Figure 1

The long-term annual data on adult salmon count 1973-2018. 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 2009 has been collected by the GWCT.

Releasing an adult salmon. © Paul Bullimore

Interreg France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

A. Adult salmon estimate

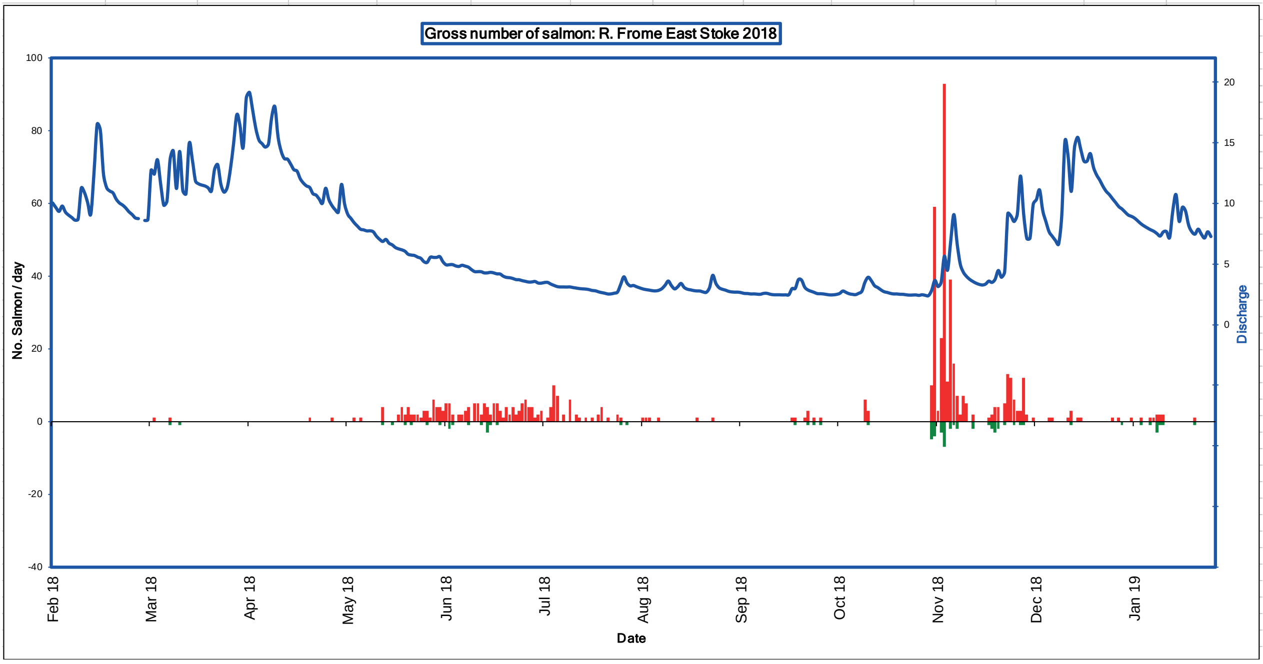
We estimate the number of returning adults using a resistivity counter that detects the change in electrical resistance of the water caused by a salmon swimming over the counter. As well as providing population data, the adult counter provides information on migration timing and the environmental factors that influence this (please contact us for a detailed report from the salmon counter). 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.

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

Figure 2

The monthly run data for 2018 and a graph showing daily gross up- and down-stream numbers and river flow. During the months January-March (in grey shading) 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 upstream (U/S)

Month	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Total
Gross U/S	0	2	2	38	101	55	6	8	9	324	30	12	587
Gross D/S	0	2	0	5	11	2	0	4	1	36	3	9	73
Nett U/S	0	1	2	33	90	53	6	4	8	288	27	12	524



waveform analysis and video analysis. In 2018 we encountered problems with the mains power supply to the fish counter creating electrical noise affecting both the fish counter and the nearby PIT tag antennae. Despite these issues there were only four days in 2018 where no count data were collected and all 23 adults detected by PIT tag antennae upstream of East Stoke had also been detected at East Stoke.

Given the very low number of smolts leaving the River Frome in 2017 we expected very few one-sea-winter (1SW) fish to return to the river in 2018. This unfortunately came true. Even though the number of returning 2SW and 3SW fish was reasonable, the total number of adults returning in 2018 was 524 which is well below the 10-year average (732) owing to the low number of 1SW fish (see Figure 2). As a result of the low number of adults returning to the River Frome in 2018, the recruitment potential for juveniles emerging from the redds in 2019 is low. Although this is not good news for the salmon, it does demonstrate the predictive power of our data collection.

B. Estimate of juvenile salmon

In September each year since 2005, 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 identify individual 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.

Following heavy rain in March and April, the summer (May-October) of 2018 was the driest on record in Wessex since 1948. Conditions during the tagging campaign in late summer were excellent for electric-fishing because we had no rain. Furthermore, the combination of heavy spring rain recharging the groundwater reservoirs and good growth of *Ranunculus* ensured good juvenile habitat (see page 16 for more information on the importance of *Ranunculus* for juvenile salmonids in the River Frome). As in 2017 we encountered good numbers of young of the year parr in the catchment during our 2018 parr tagging campaign and over the 23 days of the electric-fishing we PIT tagged in excess of 10,000 salmon and 3,500 trout. Hopefully the apparent good parr density will result in a good smolt run in 2019.

We can determine how many juveniles there were in the catchment at the time of tagging from the number of tagged juveniles and the proportion of PIT tagged smolts the following spring. The estimated juvenile population in the catchment in 2017 was 121,206, which was more than the 10-year average (93,529) and nearly four times the catchment estimate for the poor recruitment year of 2016 (34,582; see Figure 3).

KEY FINDINGS

- As we predicted, the very low number of smolts leaving the River Frome in 2017 resulted in a very poor run of one-sea-winter (1SW) fish returning in 2018.
- The knock-on effect of the poor recruitment from the spawning in the winter of 2015/16 is that juvenile recruitment in 2019 and 2020 will be compromised.
- However, in 2018 we recorded a large smolt run, which might ameliorate the low recruitment potential from the 2017 smolt cohort in 2020.
- Poor recruitment from the 2015/16 spawning season was reported widely across much of England and Wales. Other rivers affected by this poor spawning season are likely to see the same effect on the number of returning adults next year as chalk stream smolts are generally a year younger than smolts from other rivers.

Rasmus Lauridsen

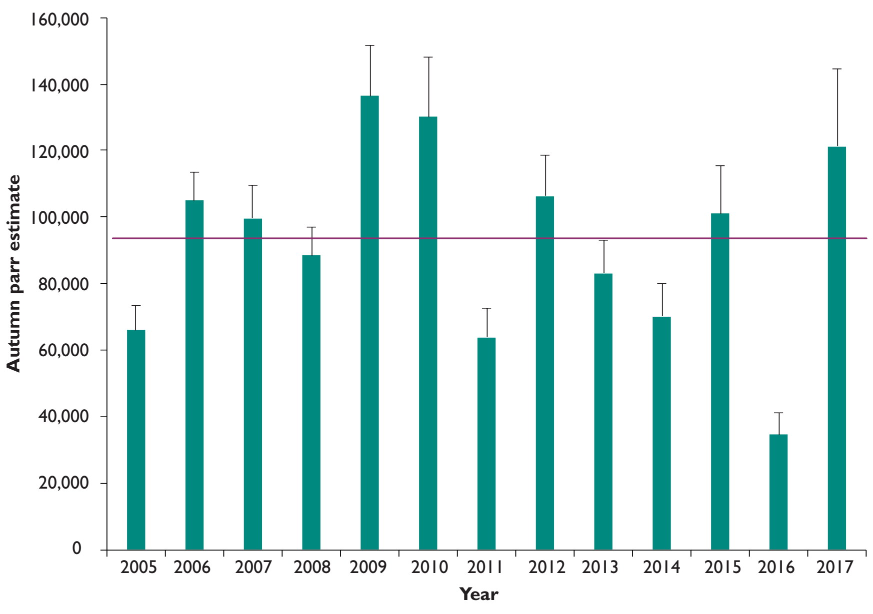
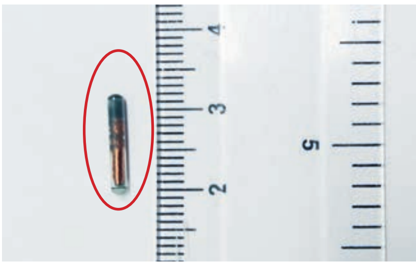


Figure 3

Estimated number of salmon parr (with 95% confidence intervals) in the Frome catchment in September 2005-2017

— 10 year average

The PIT tags are just 12mm long x 2mm in diameter.



C. Smolt estimate

PIT tag antennae on the main river at East Stoke.
© GWCT

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 (with 95% confidence intervals).

During the smolt run we normally use a device called a Bio-Acoustic Fish Fence (BAFF) to divert the fish into the Millstream at East Stoke (see map on page 5). However, in 2018 heavy rain in March and April resulted in high flows during the smolt run. Consequently, for the first time in 13 years, we were unable to deploy our BAFF. In place of the BAFF we resorted to installing a fence consisting of bubbles only, which deflected smolts albeit less efficiently, operating at 48% deflection compared with 70+% for the BAFF where the bubbles have sound entrained. In the Millstream, a proportion of the deflected fish are trapped using a rotary screw trap (RST).

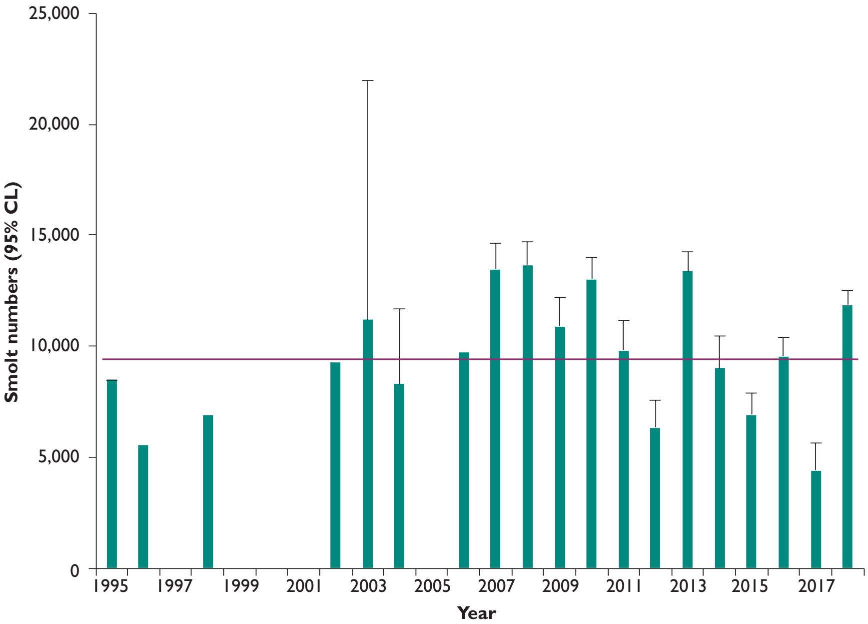
Despite the logistical issues caused by the unusually high river levels, we were able to catch enough individuals in the trap to get good smolt biometric data, to estimate the tagged to non-tagged ratio and successfully estimate the size of the 2018 smolt cohort.

The estimated number of smolts leaving the River Frome in the spring of 2018 was 11,875, which is more than double the number leaving in 2017 (4,381) and well above the 10-year average (9,511, see Figure 4). Hopefully the large 2018 smolt cohort will result in a good run of 1SW fish in 2019 ameliorating the low recruitment potential from the 2017 smolt cohort as they return as 2SW fish in 2019.

Figure 4

Estimated spring smolt population (with 95% confidence intervals) 1995-2018

10 year average



Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

11,875

the estimated number of smolts leaving the River Frome in the spring of 2018, more than double the number leaving in 2017 (4,381) and well above the 10-year average (9,511).

Getting ready to download the receivers at Saltash on the Tamar estuary. © GWCT

2. Salmon and sea trout at sea

A. Which are the fastest fish?

The life cycle of Atlantic salmon and sea trout includes both a freshwater and marine phase. Juvenile salmon and sea trout spend their first one to four years in freshwater nursery habitats. Once they reach a threshold size they smoltify and migrate to sea. At sea they grow fast taking advantage of the rich feeding grounds in the marine environment before they return as adults to the rivers where they were born to reproduce. From our work on the River Frome, we know that the mortality rate of salmon and sea trout while at sea is very high, so as part of the SAMARCH project we want to investigate the initial marine phase to study how long it takes for smolts to acclimatise to their new marine environment, as well as how dangerous this journey is for these small fish.

During the spring of 2018 we implanted acoustic tags into several hundred salmon and sea trout smolts in four rivers (Rivers Frome and Tamar in England; Rivers Bresle and Scorff in France; see map) to further our understanding of this initial marine phase.

These acoustic tags are detected by receivers deployed along the smolts' pathway from the lower river through the estuary and out to sea, allowing us to follow their migration speed and their mortality in the four estuaries.

We were surprised to discover that on average it takes only one to five days for a smolt to swim through the estuaries. Sea trout smolts travel slower, so take longer to reach the open sea than the salmon smolts and they are adopting a different estuarine behaviour. Whereas salmon leave the estuary straight away, sea trout appear to stay in the coastal area for several days before they go offshore.

On their journey out to the open sea some smolts died, probably due to predation and other natural causes. We need to have a closer look where we lost these fish and what the potential causes of mortality are as the rate varied between the four estuaries, but preliminary results show that the loss rate didn't exceed 30% in any of the estuaries.

Céline Artero has a PhD in fish ecology and conservation and is a marine biology and ecology specialist. Prior to joining the GWCT, Céline worked at the French Institute of Research for Exploitation of the Sea (Ifremer).

Interreg
France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

We implanted acoustic tags into several hundred salmon and sea trout smolts in four rivers (Rivers Frome and Tamar in England; Rivers Bresle and Scorff in France).

KEY FINDINGS

- The aim of this tracking project is to improve our knowledge of salmon and sea trout smolts in estuaries and sea trout marine migration, swimming behaviour and feeding grounds.
- The estuarine migration of 357 salmon and sea trout smolts were tracked through four estuaries in 2018.
- Smolts of both salmon and trout passed through the estuaries very quickly and in no estuary did the loss rate exceed 30%.
- From the pilot phase of the sea trout kelt tagging we have already recovered data from four fish and discovered that sea trout, while at sea, undertake intense daily diving activity to a depth of up to 50 metres.

Céline Artero

We inserted two tags in sea trout kelts. © GWCT

B. Sea trout in the marine environment

We know that our tagged salmon smolts have started a long journey to the North Atlantic, some of them travelling as far as the west coast of Greenland, before returning to our rivers in one to three years. However, we know far less about the marine journey undertaken by sea trout. In an attempt to learn more, we tagged adult sea trout using a combination of tags.

At the end of the calendar year, sea trout come back to the spawning grounds of their natal rivers to reproduce. After spawning the sea trout migrate back downstream to start another marine phase. This provides an opportunity to intercept post-spawning sea trout before they re-enter the sea.

During 2017, the pilot phase of this project, we captured 16 sea trout, eight on the River Tamar, three on the River Frome and five on the River Bresle in France. Each of these 16 fish had two tags implanted into their body cavity.

The first tag was an acoustic tag that pings every 30 seconds; these pings are detected by the same acoustic receivers deployed to detect smolts around the studied estuaries. The data downloaded from the receiver network enable us to study the migration timing, speed and mortality of sea trout in transitional waters, an area where they encounter steep gradients in water temperature and salinity.

The second tag, a data storage tag (DST), records temperature and pressure every two minutes. As fish are ectothermic (they don't regulate their internal temperature)

Figure 5

Daily maximum depth reached by a sea trout from the River Tamar from January to May 2018 based on pressure logged from an implanted tag

Céline Artero and Gregory Bennett (Environment Agency) celebrating the 'International year of the salmon' at Gunnislake trap (River Tamar). © GWCT

the temperature recorded inside the body cavity of the fish reflects the temperature of the water. Relating the temperature recorded by the DST to environmental records will enable us to reconstruct the most likely migration path of the sea trout while at sea. In the same way, the pressure recorded by the DST enables us to determine the depth at which the fish is swimming, providing information on their vertical activity. To recover the data from the DST, we need to recapture the fish, so we offer a £50 reward to anyone that recovers a DST or a tagged fish (see page 23). From the 2017 tagging we have recovered four DSTs (25% recovery rate): three individuals from the Bresle and one from the Tamar.

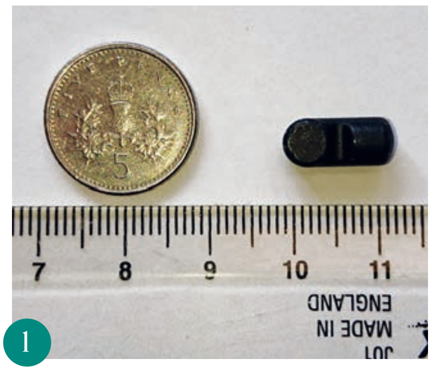
The preliminary data indicate that sea trout not only swim near the surface, as is currently assumed by specialists for management purposes, but spend a considerable time deeper than five metres and frequently dive as deep as 50 metres (see Figure 5). All four fish displayed similar behaviour with at least one dive per day, with most dives occurring during daylight hours. However, there were slight differences in daily diving pattern between the individuals from the Bresle and the one recovered Tamar tag: the Tamar fish stayed close to the surface at night whereas the Bresle fish all displayed some vertical activity at night.

We do not know yet if these vertical movements are a result of predator avoidance, feeding behaviour or other factors. In November/December 2018 we implanted tags in 99 sea trout from the three rivers and will repeat this in 2019. If we continue to have good recovery rates, we will gain unprecedented knowledge of marine behaviour and migration patterns of sea trout in the English Channel. This will enable knowledge-based management of bycatch and potentially facilitate protection of areas of special importance to a fish species that is currently in decline.

£600

is the cost of the two tags. There are also significant costs associated with catching the fish to tag it and its subsequent recapture, so this is expensive work. We would like to tag a further 150 sea trout in the winter of 2019 and are looking for funds to help us do so. If you would like to contribute then please visit www.gwct.org.uk/seatrout.

How the tags track individual fish



1 What is an acoustic tag?

An acoustic tag (above) is a small electronic tag coated with plastic that regularly emits a sound at a specific frequency. In the SAMARCH project, tags ping every 30 seconds at a 180 kHz frequency.

2 How long do the tags last?

Salmon smolts are small (11-16cm), so we are using tiny acoustic tags that will work for four months before they run out of battery. As the adult sea trout are much larger we can use bigger tags where the batteries last for two years.

3 What will we learn from the tags?

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 kelt's return migration for repeat spawning.

Data storage tags (below) record temperature and pressure (depth) every two minutes, which will inform us on what part of the water column sea trout use. The DST data will also enable us to predict their most likely migration path while at sea.

3. Does capturing and tagging wild salmon smolts affect their survival at sea?

Rotary screw traps are commonly used to catch smolts and consist of a large conical chamber with a screw thread inside, which is rotated by the river flow. © GWCT

Rasmus Lauridsen is a freshwater ecologist in our fisheries research team. He primarily does research on the migration strategy of young salmon and the drivers and consequences of different life history choices.

The GWCT has, in collaboration with the Centre for Environment, Fisheries and Aquaculture Science (Cefas), tagged around 10,000 juvenile salmon with Passive Integrated Transponder (PIT) tags in the River Frome catchment every autumn since 2005. These PIT tagged individuals are detected as the fish swim past monitoring stations, identifying the individual and informing us of when they are moving up and down the river. Coded wire tags (CWTs) are small pieces of magnetised steel with coded numbers engraved onto them and they are detected by a handheld detector that registers the presence of the tag. CWTs were used by the GWCT Fisheries team to mark seaward-migrating smolts between 2006 and 2012, in line with international standards.

What we did

All fish in this study were PIT tagged in autumn. Some of these PIT tagged individuals were then recaptured as seaward migrating smolts in spring using a rotary screw trap. Rotary screw traps are commonly used to catch smolts and consist of a large conical chamber with a screw thread inside, rotated by the river flow. The recaptured smolts were anaesthetised, had a CWT injected and allowed to recover before being released back into the river. For seven years, we collected data on PIT tagged fish in two groups:

1. Those that were captured in a rotary screw trap and marked with a CWT when migrating to sea as smolts – the 'experimental' group.
2. Those that were detected migrating to sea as smolts via their PIT tag but were not captured and marked with a CWT – the 'control' group (see Figure 6).

We compared the adult return rates of experimental and control group smolts to measure any impact of the capture and CWT process on their return rate as adults. These analyses took into account environmental conditions before and during the tagging process. The effect of individual components of the tagging process cannot be separated out, so any differences between the groups could have been caused by capture, anaesthetic, or tagging, and we cannot determine which part of the process was responsible.

Game & Wildlife CONSERVATION TRUST

Cefas

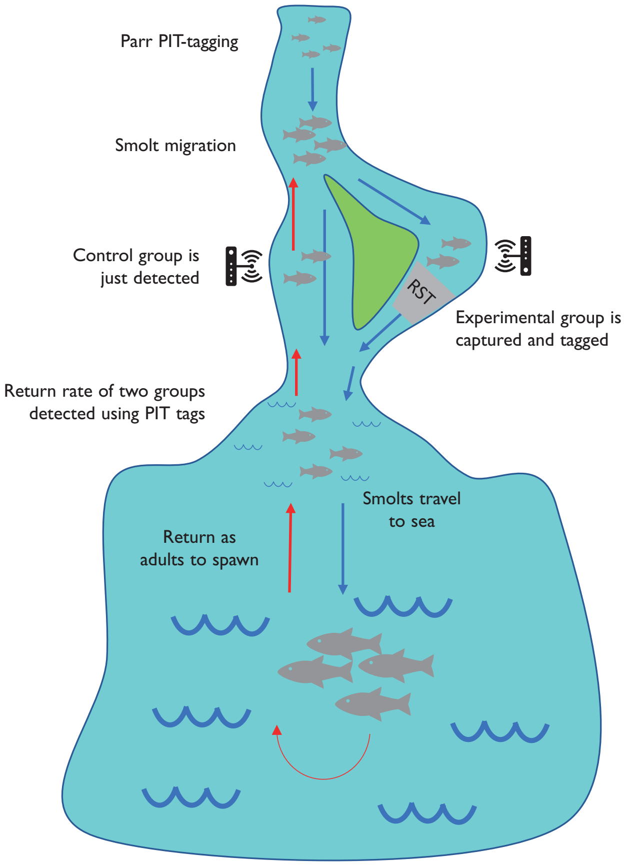


Figure 6

Schematic diagram of salmon migration to sea and back to the river and experimental design

KEY FINDINGS

- Tagging enables us to identify individual fish and is an important and widely used technique for studying wildlife. To ensure that findings from tagged individuals are not affected by the tagging process, we should monitor any effect that it has on the animal.
- We compared the adult return rate of two groups of juvenile salmon (smolts): an 'experimental' group of fish that were captured and tagged during their spring migration to sea, and a 'control' group that were not.
- Capture and tagging of smolts affected the rate at which adults returned only under certain conditions. Smolts that were caught and tagged during the night and after unusually mild winters, when river temperatures were higher, had a lower chance of returning as adults than uncaught smolts.
- The GWCT fisheries team still captures but no longer tags salmon smolts when they are migrating in spring.

Rasmus Lauridsen

Results and implications

Capture and tagging of smolts affected the rate at which adults returned only under certain conditions. In years that followed a mild winter and for fish that migrated at night, the experimental group had a lower return rate than the control group (see Figure 7). This means that fewer smolts from the experimental group returned to their home river as adults. In years with more normal weather conditions and river temperatures, the adult return rate was the same for both groups, suggesting that inserting the CWT, capture and handling did not affect the fish.

At East Stoke, we still capture a proportion of the spring smolts to collect samples, biometrics and to estimate the proportion of PIT tagged fish, but we no longer mark them with CWTs. However, these results could help guide all users of CWTs on fish to minimise their potential impact by being cautious when tagging under these conditions. View the paper online at: doi.org/10.1111/jfb.13655.

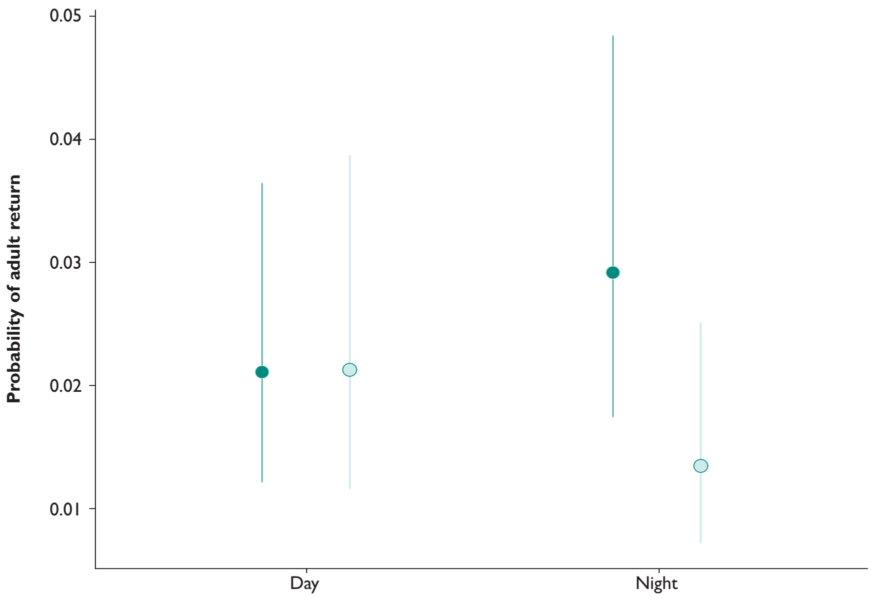


Figure 7

Probability of smolts returning depending on whether they migrated past East Stoke at day or night and whether they were captured and tagged 'Experimental group' as smolts or not 'Control group'

France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

4. Impacts of reduced discharge on salmonid ecosystems

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.

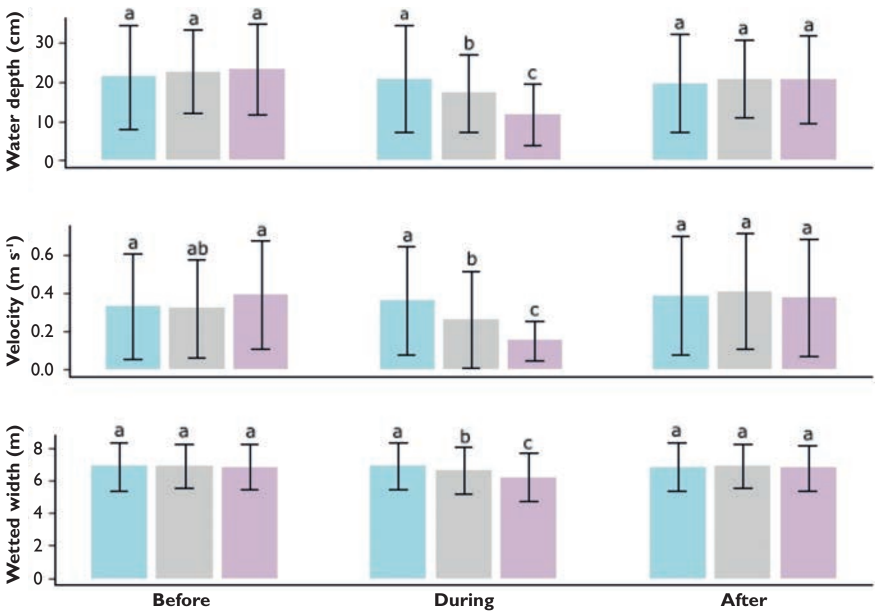
Chalk streams are characterised by naturally stable flow regimes as they are fed primarily by groundwater, but climate change and extensive human water abstraction is predicted to increase the frequency and intensity of short-term summer droughts. In this study, undertaken in three carriers of the River Itchen in Winchester, we explored abiotic and biotic responses of chalk streams to reduced discharge. Three discharge reduction treatments were applied: control (no change), 50% reduction and 90% reduction, to each stream, with one treatment per summer across three summers. Reduction treatments lasted for 25 days: the level of reductions were set relative to natural variations in flow variations recorded on the River Itchen during the summer (1976-2008 inclusive). Sampling took place on three occasions each year: before, during and after discharge manipulation.

Discharge reduction resulted in significant reductions in water depth, velocity and wetted width (see Figure 8). Overall, on average, the 90% discharge reduction treatment resulted in a 49% decrease in water depth, 48% reduction in velocity and a 15% reduction in wetted width. Once discharge had been reinstated to pre-

Figure 8

Variation in water depth (cm), velocity (m s^{-1}) and wetted width (m) among treatments across sampling occasions (mean ± SD). Results of post-hoc tests shown, where mean values sharing the same letter are not significantly different

Control
50% reduction
90% reduction



One of the sluice gates enabling us to control the discharge on the carriers of the River Itchen. © GWCT

Jessica Picken sampling invertebrates. © *GWCT*

manipulation levels, there were no significant differences in water depth, velocity and wetted width compared with before.

Despite the experimental discharge reduction having a clear and substantial impact on the physical characteristics of the study streams, the effects on the standing stock of basal resources and on the macroinvertebrate communities were limited. Even though the available area of wetted habitat decreased, reduced discharge had no detectable effect on the density or biomass of macroinvertebrates and only very minor effects on macroinvertebrate community composition. It appears that the macroinvertebrate communities in these chalk streams were resistant to the imposed short-term droughts.

The imposed discharge reduction also had limited effect on the salmonid populations in the three streams. Even though reduced discharge altered the physical characteristics of these chalk streams substantially, such effects did not necessarily propagate into change at higher ecosystem levels.

Although the 25-day-long experimental reduction in discharge had limited effect on macroinvertebrates and fish at the population level, preliminary results suggest that larger trout left the drought effected areas during the discharge reduction, an effect particularly pronounced during the 90% reduction (see Table 1). We are currently analysing data on habitat choice and the behaviour of individual PIT tagged fish before, during and after the discharge manipulation to understand better how they deal with reduced discharge.

TABLE 1

Trout were PIT tagged when captured during the 'before' fishing occasion and PIT tag detections from the PIT tag antenna at the downstream end of one of the streams showed how many fish left the site during the discharge manipulation period

Treatment	1+ Trout (% of population leaving)	Older Trout (% of population leaving)
Control	1.0	1.6
50% reduction	2.9	3.7
90% reduction	8.8	31.0

KEY FINDINGS

- The imposed reduction in discharge had a substantial impact on the physical characteristics reducing depth, water velocity and channel width.
- Despite the effects on physical characteristics, discharge reduction had limited effect on the amount of basal resources and it appeared that the macroinvertebrate community in these chalk streams were remarkably resistant to the imposed 25-day discharge reduction.
- Even though the effect on the salmonid density of the discharge reduction was limited, preliminary results from PIT tag readers suggest that larger trout left the drought effected areas during the 90% reduction.
- We are currently analysing trout habitat choice before, during and after discharge reduction.

Jessica Picken

5. Juvenile salmonid densities and habitat

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.

Understanding the habitat requirements of juvenile salmonids is vital if we are to better manage their freshwater environment. Although habitat variables influencing salmonid densities (water depth and velocity, river-bed substrate, in-stream cover) have previously been identified, their relative importance is poorly understood particularly in lowland rivers.

In place of large cobble and boulder substrates, which are favoured by juvenile salmonids in high-energy rivers, our low-energy chalk streams feature dominant *Ranunculus* (water crowfoot) beds, which may offer shelter from both predators and high water velocities. *Ranunculus* encourages complex habitats to develop with a mix of water velocities. This is beneficial to juvenile salmonids because they use high velocity habitats for foraging. They maintain position in low velocity adjacent to a section of high velocity that brings their macroinvertebrate prey to them, so they can dart out to capture prey without expending too much energy. While this is well-documented foraging behaviour, previous studies have not attempted to record a measure of this variability in water velocity and relate that to salmonid densities.

An additional consideration, which has been overlooked in much of the literature, is the influence of the colonisation potential of a site. After emergence from spawning redds (nests), salmonid fry will disperse downstream until they reach suitable habitat to feed and grow before overwintering, therefore the proximity of redds to a site could influence the densities found there.

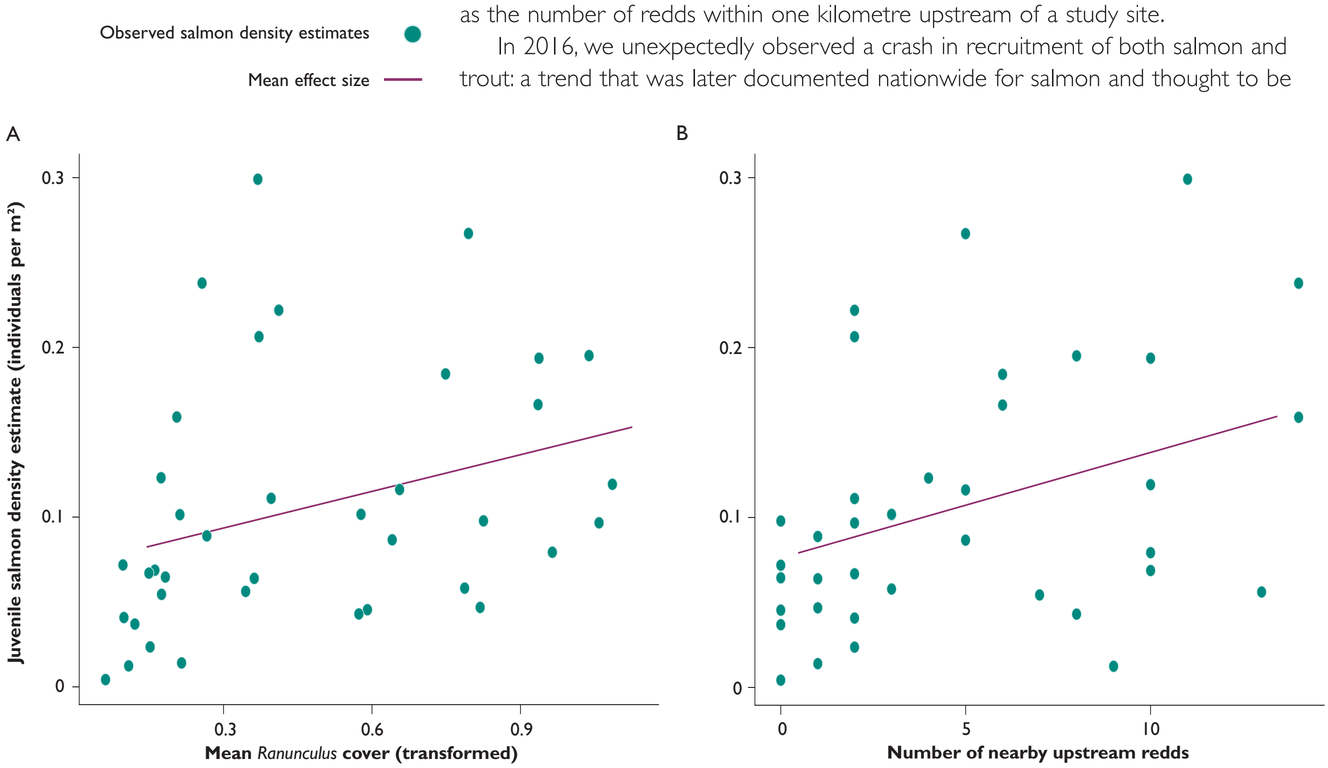
This study aimed to incorporate both the traditional habitat variables and novel considerations of mixed water velocity and redd proximity to best describe densities of juvenile Atlantic salmon and brown trout in a chalk stream.

For three years (2015-2017) in late summer, we sampled about 20 sites throughout the River Frome catchment, recording juvenile salmon and trout densities, habitat characteristics (observed in 50 quadrats per site: *Ranunculus* cover, water depth, proportion of fast and slow velocities, river substrate) and prey abundance (macroinvertebrates). To represent how mixed the water velocities were at a site, we aimed to capture the difference in velocity between neighbouring quadrats. We calculated the mean steepness of gradients in velocity between adjacent quadrats and averaged their absolute values to represent a site-level variable. We also used an annual salmon redd survey that is carried out on the Frome and its main tributaries, and determined site colonisation potential as the number of redds within one kilometre upstream of a study site.

In 2016, we unexpectedly observed a crash in recruitment of both salmon and trout: a trend that was later documented nationwide for salmon and thought to be

Figure 9a & b

Juvenile salmon density increases with increasing (a) *Ranunculus* cover and (b) number of nearby upstream redds, after taking into account the effects of other variables



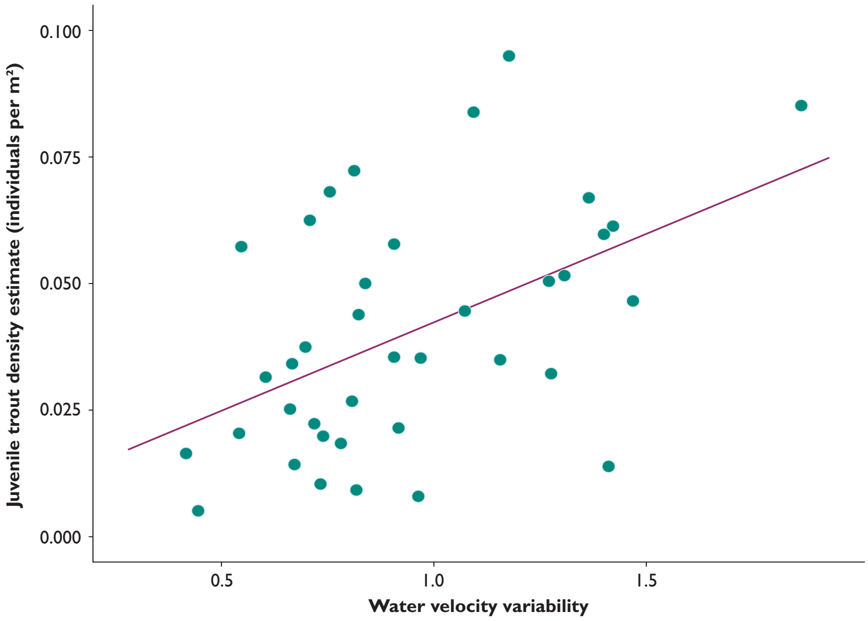


Figure 10

Juvenile trout density increases with increasing variability in water velocity, after taking into account the effects of other variables.
(x axis scale: 0 = constant water velocity; 2 = high velocity variability)

● Observed trout density estimates

— Mean effect size

Juvenile salmon (top) and trout (bottom) showing differences in morphology (notably the tail fork) and body colouration and patterns. © GWCT

caused by an especially warm and wet winter in 2015/16, which affected egg survival. Therefore, we decided to investigate fish density-habitat relationships both including and excluding this unusual year.

For both species, densities were reduced by at least 50% in the 'unusual' year relative to the two other years, driven by the dip in recruitment success in 2016. This highlights the overriding influence of recruitment success on the juveniles. In 'normal' years, juvenile salmon densities were best predicted by and positively associated with increasing *Ranunculus* cover, proportion of fast velocities and number of nearby upstream redds (see Figure 9a & b). These variables jointly explained 26% of the observed variance in salmon densities. In both 'normal' and 'unusual' years, water velocity variability was found to be an important predictor of trout densities, which were positively associated with more mixed velocities (see Figure 10). This could demonstrate an indirect influence of *Ranunculus* on trout densities, through its effect on water velocities.

Our study describes habitat characteristics that promote abundant juvenile salmon and trout in lowland chalk streams. Both an unexpected recruitment crash during this study and the importance of proximity to redds highlight the need to consider the influence of recruitment to habitat patches when exploring density-habitat associations. Additionally, knowledge of annual redd distributions would allow for more focused habitat conservation of sites with high colonisation potential, which our results suggest support higher juvenile densities. Our results suggest that salmon and trout have different habitat requirements and so ensuring in-stream habitat complexity could benefit both species. However, *Ranunculus* cover could be a key habitat characteristic for both species, either directly or by creating desirable habitat conditions. These findings are likely to be applicable to other lowland salmonid streams where *Ranunculus* plays a pivotal role in structuring the habitat.

KEY FINDINGS

- We found that juvenile salmon densities were positively associated with *Ranunculus* cover, fast velocities and proximity to spawning redds.
- Stretches of the river with a mix of fast and slow velocities were associated with the highest juvenile trout densities.
- The observed crash in recruitment in 2016 highlights the sensitivities of salmonid populations to larger themes, such as climate change.

Jessica Marsh

Typical chalk stream habitat: mosaic of Ranunculus *beds on the River Frome. © GWCT.*

6. Atlantic salmon return rate and smolt length

Return rate is higher for longer smolts. © GWCT

Stephen Gregory is our fisheries ecologist and statistician. He is a keen conservationist who uses population dynamics modelling to inform management of endangered populations and species.

Atlantic salmon stocks (as indicated by catches) are declining. For a long time, blame has been pointed at the marine environment, where climate change and the processes it influences, such as water temperature, sea-level and the place and timings of 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 juvenile development in the freshwater might affect their success at sea. Specifically, there is a long-standing but hitherto untested theory that smolt size is related to its survival at sea, ie. the smaller you are, the less likely you are to survive.

As part of our work towards SAMARCH, we designed a study to test the effect of smolt length on their subsequent marine return rate. To test our hypothesis, we developed a statistical model that would account for issues in other studies designed to test this hypothesis, including: (1) The time individuals spend at sea, which is thought to be related to marine mortality rates; (2) Variation in marine return rate due to other variables, such as years; (3) Imperfect detection of returning adults due to inefficiency in monitoring devices; and (4) Data loss due to failure of monitoring devices.

We applied our model to data collected on the River Frome in Dorset, because the quantity and quality of the data are unsurpassed and could support such a sophisticated statistical analysis. Individual salmon smolts emigrating from and returning to the River Frome have been monitored using passive integrated transponder (PIT) tags since 2006. Each autumn, approximately 10,000 individual juvenile salmon are captured, marked with a PIT tag under anaesthesia, and returned to the river at their site of capture. In the following spring, these parr migrate to sea as smolts. We capture a representative sample of them in a rotary screw trap and measure and weigh them. All captured smolts are then returned to the river 50 metres downstream, within one hour of their capture, to continue their migration to sea.

Returning adult salmon are detected on two PIT antenna arrays installed eight kilometres (km) and 11.5km upstream of the tidal limit, the second of which was not operational for the first five years of monitoring.

We compared three statistical models. The models were all developed to allow for imperfect detection of adults and loss of data, and estimated the effect of smolt length on the survival after one winter at sea (also known as a 1 sea-winter or 1SW salmon) and two winters at sea (2SW). Careful comparison of the models revealed highest statistical support for the 'Length' model, which suggested that the effect of length was strong and positive: over all the years analysed, the effect of smolt length was to increase their subsequent 1SW return rate from 0.95% (credible range: 0.95-0.96) for a 120mm smolt to 3.42% (credible range: 2.56-4.54) for a 160mm smolt

KEY FINDINGS

- GWCT fisheries salmon data is unparalleled in quality and quantity and was used to develop a statistical model to test the longstanding, but hitherto untested, hypothesis that larger smolt survive at sea better than smaller smolts.
- We found credible evidence for an effect of smolt length on their survival at sea.
- It appears that a 16cm smolt is three to four times more likely to survive at sea compared with a 12cm smolt.

Stephen Gregory

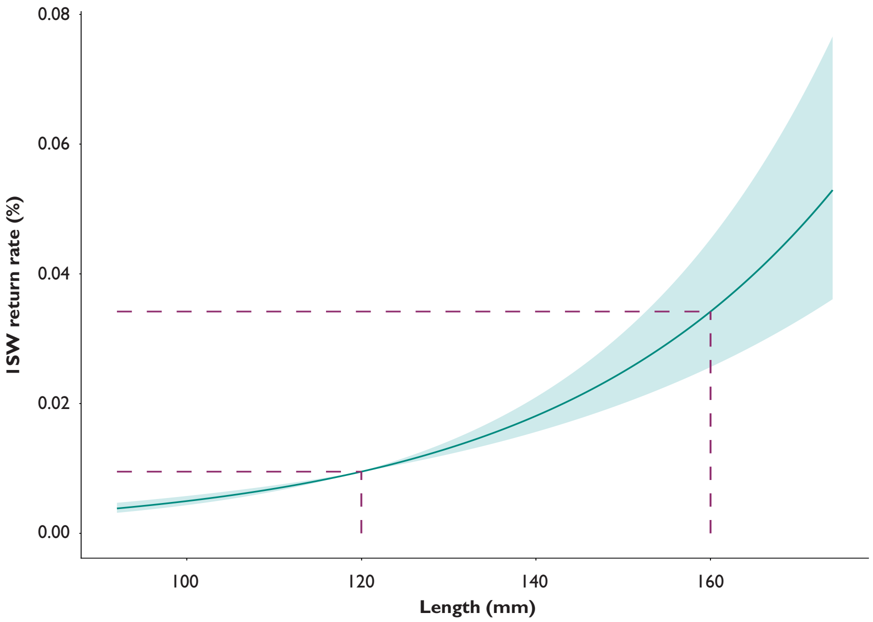


Figure 11
Smolt length has a considerable effect on the probability of the individual returning to its natal river to spawn: among one year old smolts a 16cm smolt is three to four times more likely to return as an adult compared with a 12cm smolt

(see Figure 11), 120-160mm being the normal range of observed smolt lengths on the River Frome.

In conclusion, this study presents credible evidence for an effect of Atlantic salmon smolt length on their subsequent 1SW marine return rate. Our findings therefore add support to the growing, yet still equivocal, evidence that 'bigger is better' among salmon smolts. The precise mechanism of this effect deserves further study but could include differences in predator avoidance due to size or swimming ability or different migration routes. Our model also provides a flexible approach to exploring the generality of this pattern, across rivers and datasets. Most importantly our findings suggest that factors affecting salmon in their freshwater phase have a significant influence on their later life stages, including those at sea, and thus affects their fitness. Since it is easier to affect management actions in the freshwater relative to the marine environment, in-river conditions, such as habitat cover and food availability, could be managed to nurture larger and better condition salmon smolts, particularly on the River Frome where recent work has already revealed that salmon juveniles are decreasing in size.

View the paper online at: doi.org/10.1093/icesjms/fsz066.

Game & Wildlife CONSERVATION TRUST
Bournemouth University
Cefas
Interreg France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

How to estimate smolt abundance

1

We mark approximately 10,000 freshwater juvenile salmon (parr) with a PIT tag in the autumn preceding the annual spring smolt migration to sea. These marked parr will be the subjects in our mark-recapture experiment, which allows us to estimate the number of migrating smolts.

2

The following spring, we detect smolts carrying PIT tags on two PIT antennae: one in the fluvarium and one downstream on the Millstream gauging weir. We can then estimate the total number of marked smolts that passed the antennas.

3

Alongside the mark-recapture experiment, we capture a sample of the migrating smolts to estimate the proportion of migrating smolts that are marked with a PIT tag. We can use this to work out the total number of smolts migrating to sea.

7. Overwinter growth of juvenile salmon

Olivia Simmons is a PhD student working with the GWCT and Bournemouth University studying the implications of changes in the migration phenology of Atlantic salmon

The growth of juvenile Atlantic salmon while in the river, before they 'smoltify', is thought to be very important, as it is hypothesised that the size attained by the juveniles at the onset of their migration to saltwater has consequences for their subsequent survival. In the River Frome, as in many rivers throughout the Northern Hemisphere, fewer salmon are surviving to adulthood and making successful migrations back to their natal rivers to spawn. As such, it is of great interest to determine what factors affect the overwinter growth rate (ie. how quickly each individual grows) of Frome salmon.

In the northern parts of the salmon's distribution, rivers are too cold for the fish to continue to grow during winter months. However, in southern parts of the salmon's distribution, rivers can stay warm enough throughout the winter for the fish to continue to feed and grow during this season. The Frome is one such river that remains warm enough for most of the winter to allow the fish to grow and attain a body length suitable for migrating in the spring.

During the spring smolt migration a sample of the 10,000 individuals that were PIT tagged the previous autumn are recaptured in a rotary screw trap in the River Frome (see page 8 and 12). Individuals that were previously PIT tagged are identified and re-measured. The data from these two length measurements forms the basis of this work.

A metric known as the 'specific growth rate' was calculated for every individual captured as a parr and recaptured as a smolt between 2005-2018. To determine which factors affect the overwinter growth rate of each individual, a model was developed for 50 sites throughout the Frome catchment. A number of biotic and abiotic variables were tested and the following six had a significant effect on overwinter growth rate: 1) Coefficient of variation in water temperature (CV temperature), which is a measure of the variation in water temperature between date of capture and recapture; 2) Coefficient of variation in water discharge (CV flow), which is the variation in river discharge between the date of capture and recapture; 3) Duration of high flow events during the autumn, which is defined as the number of days when the discharge is ≥Q10 (the upper 10 percentile of discharge) between the date of capture and the beginning of January; 4) Length of parr at time of initial capture; 5) Relative density of parr measured as the number of fish captured at each site; 6) Distance upstream, which is a measurement in kilometres of how far upstream from the RST the fish were captured in the autumn. Degree days, which is the sum of the average daily water temperatures between the date of initial capture and subsequent recapture, is also included in the model, although the results show it to have an insignificant effect on the growth rate (see Figure 12).

KEY FINDINGS

- What affects the growth rates of juvenile salmon during the winter months prior to their spring migration?
- Variation in water temperature and flow, the duration of high flow events and the relative density of individuals in the river were all found to negatively affect salmon growth.
- Preliminary findings suggest that the more variable river conditions that may result from climate change could result in lower growth rates for juvenile salmon in the near future.

Olivia Simmons

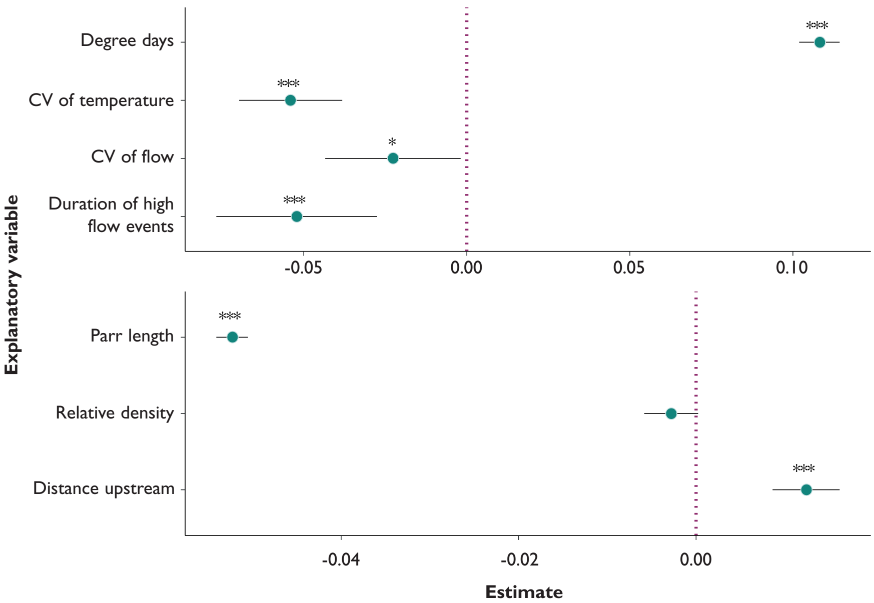


Figure 12

Caterpillar plot of maximum likelihood estimates of fixed effects. The point is the estimated value, the lines show the standard errors for each value, and the asterisks indicate statistical significance, where ** = $p<0.01$ and ***= $p<0.001$

Interreg France (Channel Manche) England
SAMARCH
SAlmonid MAnagement Round the CHannel
European Regional Development Fund

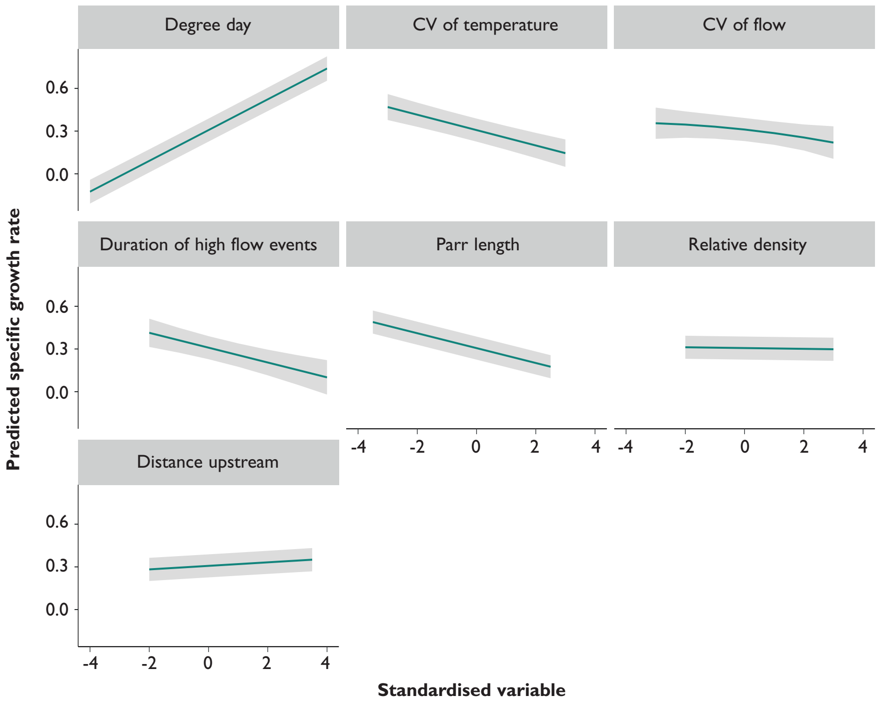


Figure 13

Line plots of the marginal effects of each fixed effect (the estimated effect of a given variable when all other variables are kept fixed). The shaded grey area is the standard error of the estimated effect

Although results are still preliminary, some interesting patterns have emerged (see Figure 13). The distance upstream had a positive effect on the overwinter growth rate of the juvenile salmon. This means that fish that resided further upstream tended to grow more quickly than individuals who resided further downstream. The CV temperature, CV flow, duration of high flow events, parr length, and relative density all had negative effects on overwinter growth. This means that fish that experienced more variation in temperature and flow had slower growth rates than those that did not. Fish that experienced more high flow days also had slower growth rates than those that did not. Additionally, larger parr tended to grow more slowly over winter than smaller parr. Finally, fish from more densely inhabited sites grew more slowly than those from less densely inhabited sites.

What are the implications of these early findings? The results of the climate variables are particularly noteworthy. As our climate changes weather is going to be less predictable. The negative effects of variation in temperature and flow suggest that greater variation in the conditions of the river will reduce overwinter growth. With the world changing in unpredictable ways, the study of this valuable species is crucial to develop management plans to mitigate the worst of these consequences.

Capturing parr for PIT tagging. © GWCT.

8. Scientific publications

2018

Angulo, E, Luque, G, **Gregory, SD**, Wenzel, JW, Bessa-Gomes, C, Berec, L and Courchamp, F (2018) Allee effects in social species. *Journal of Animal Ecology*, 87, 47-58. DOI: 10.1111/1365-2656.12759.

Bašić, T, Britton, JR, Cove, RJ, **Ibbotson, AT** and **Gregory, SD** (2018) Roles of flow and temperature on the recruitment of European grayling *Thymallus thymallus* at its southern limit. *Ecology of Freshwater Fish*, 27, 940-951. DOI: 10.1111/eff.12405.

Gregory, SD, Armstrong, JD & Britton, JR (2018) Is bigger really better? Towards improved models for testing how Atlantic salmon *Salmo salar* smolt size impacts marine survival. *Journal of Fish Biology*, 92, 579-592. DOI: 10.1111/jfb.13550.

Gregory, SD (2018) Could bigger be better? Longer Atlantic salmon smolts seem more likely to return as adults. *Proceedings of the 33rd International Workshop on Statistical Modelling*, Volume I, p. 112-117.

Ikediashi, C, Paris, JR, King, RW, **Beaumont, WRC, Ibbotson, AT** and Stevens, JR (2018) Atlantic salmon *(Salmo salar L.)* in the chalk streams of England are genetically unique. *Journal of Fish Biology*, 92, 621-641. DOI: 10.1111/jfb.13538.

Milner, AM, **Picken, JL**, Klaar, MJ, Robertson, AL, Clitherow, LR, Eagle, L and Brown, LE (2018) River ecosystem resilience to extreme flood events. *Ecology and Evolution*. DOI: 10.1002/ece3.4300.

Moore, A, Privitera, L, Ives, MJ, Uzyczak, J and **Beaumont, WRC** (2018) The effects of a small hydropower scheme on the migratory behaviour of Atlantic salmon *Salmo salar* smolts. *Journal of Fish Biology*, 93, 469-476. DOI: 10.1111/jfb.13660.

Parry E, Gregory SD, Lauridsen RB and Griffiths, S (2018) The effects of flow on Atlantic salmon *(Salmo salar)* redd distribution in a UK chalk stream between 1980 and 2015. *Ecology of Freshwater Fish*, 27, 128-137. DOI: 10.1111/eff.12330.

Perkins, DM, Durance, I, Edwards, FK, Grey, J, Hildrew, AG, Jackson, M, Jones, JI, **Lauridsen, RB**, Layer-Dobra, K, Thompson, MS, Woodward, G and Mouillot, D (online early) Bending the rules: exploitation of allochthonous resources by a top-predator modifies size-abundance scaling in stream food webs. *Ecology Letters*. DOI: 10.1111/ele.13147.

Riley, WD, **Ibbotson, AI, Gregory, SD**, Russell, IC, **Lauridsen, RB, Beaumont, WRC**, Cook, AC and Maxwell, DL (2018) Under what circumstances does the capture and tagging of wild Atlantic salmon *Salmo salar* smolts impact return probability as adults? *Journal of Fish Biology*, 93, 477-489. DOI: 10.1111/jfb.13655.

2017

Beaumont, WRC (2017) Rates and effects of branding due to electroshock (Dagit and Krug 2016): Some additional perspectives. *North American Journal of Fisheries Management*, 2, 429-430. DOI: 10.1080/02755947.2017.1280570.

Fernandes, WPA, Griffiths, SW, **Ibbotson, AT** and Riley, WD (2017) Relatedness and body size influence territorial behaviour in *Salmo salar* juveniles in the wild. *Fisheries Management and Ecology*, 24, 347-351. DOI: 10.1111/fme.12234.

Gregory, SD, Nevoux, M, Riley, WD, **Beaumont, WRC**, Jeannot, N, **Lauridsen, RB**, Marchand, F, **Scott, LJ**, and Roussel, JM (2017) Patterns on a parr: drivers of long-term salmon parr length in UK and French rivers depends on geographical scale. *Freshwater Biology*, 62, 1117-1129. DOI: 10.1111/fwb.12929.

Kemp, PS, Vowles, AS, **Roberts, D, Sotherton, N**, Acreman, MC and Karageorgopoulos, P (2017) Challenging convention: the winter ecology of brown trout *(Salmo trutta)* in a productive and stable environment. *Freshwater Biology*, 62, 146-160. DOI: 10.1111/fwb.12858.

Lauridsen, RB, Moore, A, **Gregory, SD, Beaumont, WRC**, Privitera, L and Kavanagh, JA (2017) Migration behaviour and loss rate of trout smolts in the transitional zone between freshwater and saltwater. In: *Sea Trout: Science & Management*. p 292-307.

Moore, A, **Lauridsen, RB,** Privitera, L and **Beaumont, WRC** (2017) The impact of a small hydropower scheme on the migratory behaviour of sea trout *(Salmo trutta L.)* smolts in the River Frome, southern England. In: *Sea Trout: Science & Management*. p. 541-554.

2016

Phang, SC, Stillman, RA, Cucherousset, J, Britton, JR, **Roberts, D, Beaumont, WRC** and Gozlan, RE (2016) FishMORPH – an agent-based model to predict salmonid growth and distribution responses under natural and low flows. *Scientific Reports*, 629414. DOI: 10.1038/srep29414.

Pinder, AC, Hopkins, E, **Scott, LJ** and Britton, JR (2016) Rapid visual assessment of spawning activity and associated habitat utilisation of sea lamprey (*Petromyzon marinus* Linnaeus, 1758) in a chalk stream: implications for conservation monitoring. *Journal of Applied Ichthyology*, 32, 364-368. DOI: 10.1111/jai.13010.

Goodwin, JCA, King, RA, Jones, JI, **Ibbotson, AT** and Stevens, JR (2016) A small number of anadromous females drive reproduction in a brown trout *(Salmo trutta)* population in an English chalk stream catchment. *Freshwater Biology*, 61, 1075-1089. DOI: 10.1111/fwb.12768.

GWCT staff in bold.

£50 REWARD

IF YOU FIND A SEA TROUT WITH A TAG

AND/OR A BLUE TATTOO

THERE IS AN ELECTRONIC TAG INSIDE

Electronic tag inside fish

PLEASE KEEP THE WHOLE FISH AND CONTACT

GAME & WILDLIFE CONSERVATION TRUST

CÉLINE ARTERO

Email : tags@gwct.org.uk

Phone : 01929 401 896 / 07525 913 086

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

WITH DATE AND LOCATION OF THE RECOVERY

Interreg France (Channel Manche) England SAMARCH

The Game & Wildlife Conservation Trust

For more than 80 years our scientists have been researching why species like the grey partridge, corn bunting and black grouse have declined. We are continually developing practical measures to reverse these declines.

Our aim is simple – a thriving countryside rich in game and other wildlife.

We are an independent charity reliant on voluntary donations and the support of people who care about the survival of our natural heritage.

Our science is funded by our members. Be the first to know about our new research and call 01425 651010 to join us today.

Game & Wildlife
CONSERVATION TRUST

Salmon & Trout Research Centre,
East Stoke, Wareham,
Dorset, BH20 6BB
Tel: 01929 401894
Email: fisheries@gwct.org.uk

www.gwct.org.uk

Editing, design and layout: Louise Shervington
Printed on recycled paper