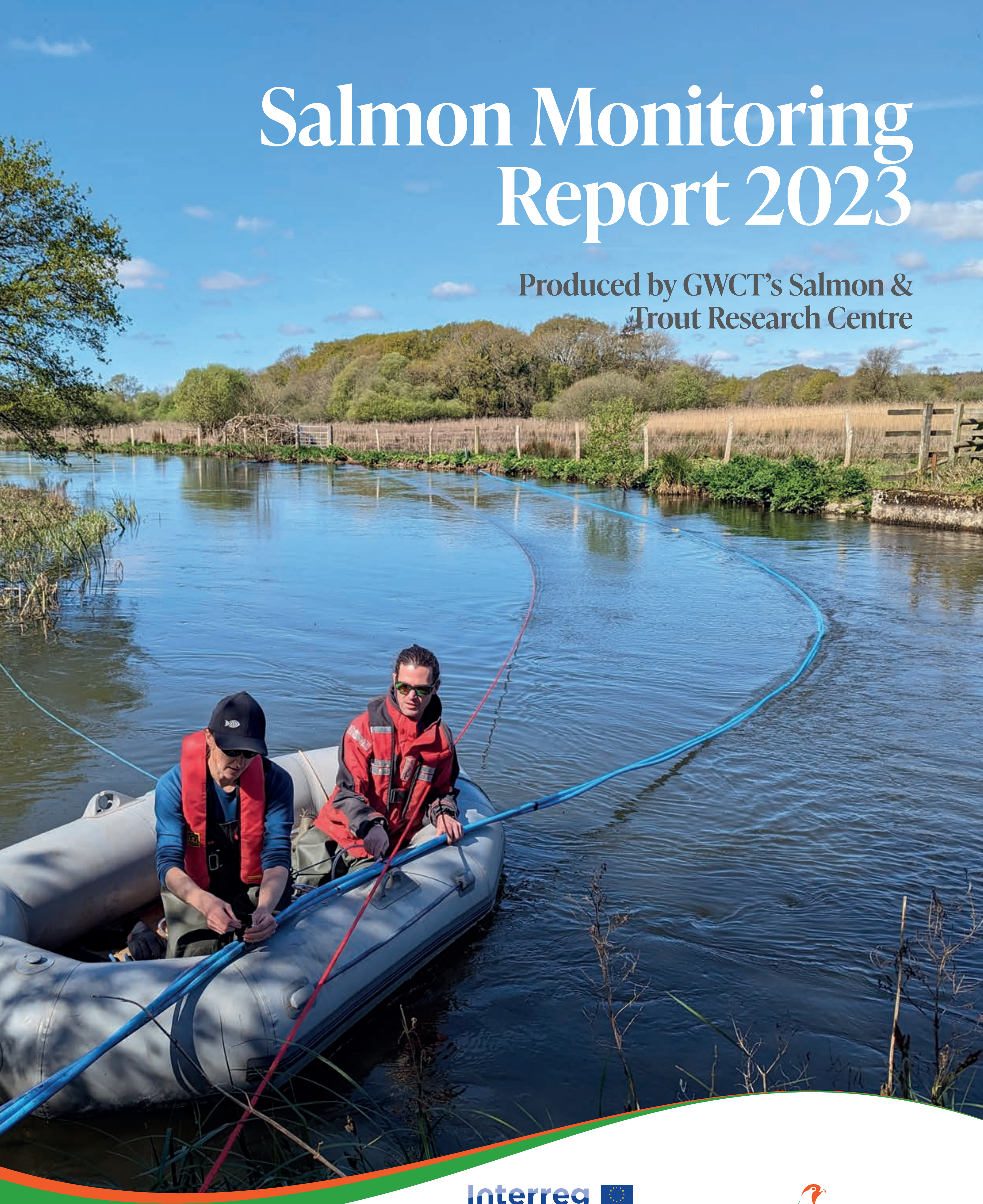


Salmon Monitoring Report 2023

Produced by GWCT's Salmon & Trout Research Centre

THE MISSING SALMON ALLIANCE

Game & Wildlife Conservation Trust | Angling Trust | Fisheries Management Scotland | The Rivers Trust

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

Environment Agency

Game & Wildlife CONSERVATION TRUST

Contents

INTELLECTUAL PROPERTY RIGHTS

This monitoring is part of the SAMARCH project and is part-funded by the EU's Interreg VA Channel Programme, **www.samarch.org**

Foreword

By Sophie Elliott, Senior Fisheries Scientist Game & Wildlife Conservation Trust

Sophie Elliott

It has been a challenging winter and spring season for the fish research team here at the River Lab. The exceptionally high rainfall (the wettest winter since 1874 according to Wessex Water) has led to extremely high river levels, making it impossible for us to carry out much of our field work and shortening other parts, affecting population estimates.

The Atlantic salmon redd counts (counting salmon nests via a drone and on foot from the riverbank) that were due to take place in January, had to be abandoned due to flooded banks and poor water visibility, and the annual smolt monitoring was delayed by a month, leading to us missing most of the sea trout migration.

Further, a breach from the River Frome into the Millstream where our smolt trap and processing lab are located has occurred because of erosion. This breach between the rivers meant we could only operate the trap under lower flows when the fish were less likely to migrate. This year's exceptionally high river flow therefore meant that the start of the fish trapping was delayed, which shortened the monitoring period. The breach needs to be repaired if we are to continue to make accurate population estimates – something we have been doing here since 2006. These population assessments are of particular importance given the River Frome is an 'index river' for which population estimates feed into national and international population assessments.

We have a busy summer in front of us, but also an exciting European eel (IUCN red-listed as Critically Endangered) tagging project to look forward to.

GWCT authors

Sophie Elliott
Luke Scott
Will Beaumont
Jess Marsh
Bill Beaumont
Keerthan Boraiah
Tommy Tham
Dylan Roberts

The salmon population monitoring is carried out on the River Frome.

1. Summary

This report summarises the salmon population monitoring carried out on the River Frome by the Game & Wildlife Conservation Trust (GWCT) at its Salmon & Trout Research Centre during the 2023 salmon year (1 February 2023 to the end of January 2024), followed by the methods used, which change minimally between years.

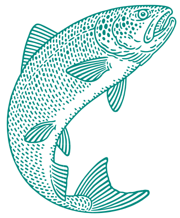
The nett upstream adult count of salmon for 2023 from the East Stoke resistivity counter was 443 fish (see Table 1 and 3), which is 22% down on the 10-year average (see Table 1; Figure 1). The largest salmon recorded by the video at the resistivity counter was 116cm with a mean MSW size of 87cm (SD 10cm). From video observations the 2023 run of adult fish was dominated by multi-sea winter fish (56%; see Figure 2 and 11).

Based on the detection of Passive Integrated Transponder (PIT) tagged returning adult salmon from smolts, the marine return rate ('survival') of 1SW fish was 0.36%, which is well below the long-term average (2013-2023, 2.49%). The return rate of 2SW salmon was 1.11% which is just below average (2014-2023, 1.94%) (see Table 2, Figure 2).

We estimated that there were just over 142,908 salmon parr in the River Frome catchment in September 2023 which is 50% above the 10-year average, as opposed to in 2022 where it was 7% below average (see Figure 3). Our 2023 salmon smolt estimate was 10,963 ± 1,423 (95% confidence interval), which is 16% above the 10-year average (9,465; see Figure 4).

HIGHLIGHTS

- The nett upstream adult count of salmon for 2023 from the East Stoke resistivity counter was 443 fish, which is 22% down on the 10-year average.
- There has been an increase in MSW returning salmon detected by video images (up 14% from the 10-year average), but a decrease in 1SW salmon (down 14% from the 10-year average).
- The estimated salmon parr in the River Frome catchment in September 2023 was 50% above the 10-year average.
- We put in place a new Wolf trap to capture smolts which has much better efficiency at catching smolts than the previous Rotary Screw Trap (RST).
- The estimated number of salmon smolts at East Stoke in 2023 was 10,963 with a confidence interval of ± 1,423 (Figure 4). This is 16% above the 10-year average (9,465).



The nett upstream adult count of salmon for 2023 from the East Stoke resistivity counter was 443 fish, which is 22% down on the 10-year average.

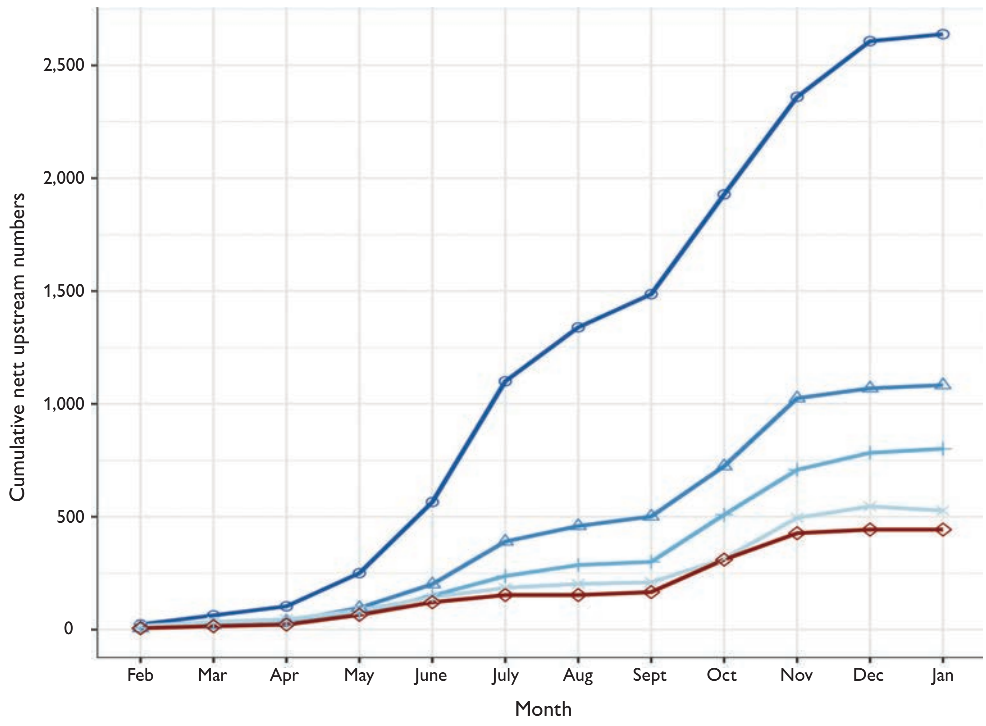


Figure 1
Cumulative nett upstream adult salmon count for 2023 and the average for the most recent 10 years recorded by the resistivity counter at East Stoke

TABLE 1

Cumulative monthly Nett upstream movement of salmon over the year and their 10-year average

MONTH	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN' 24
Cumulative no.	6	15	22	65	121	153	153	166	310	427	443	443
10-year average	16	35	45	86	142	185	201	209	314	495	546	527

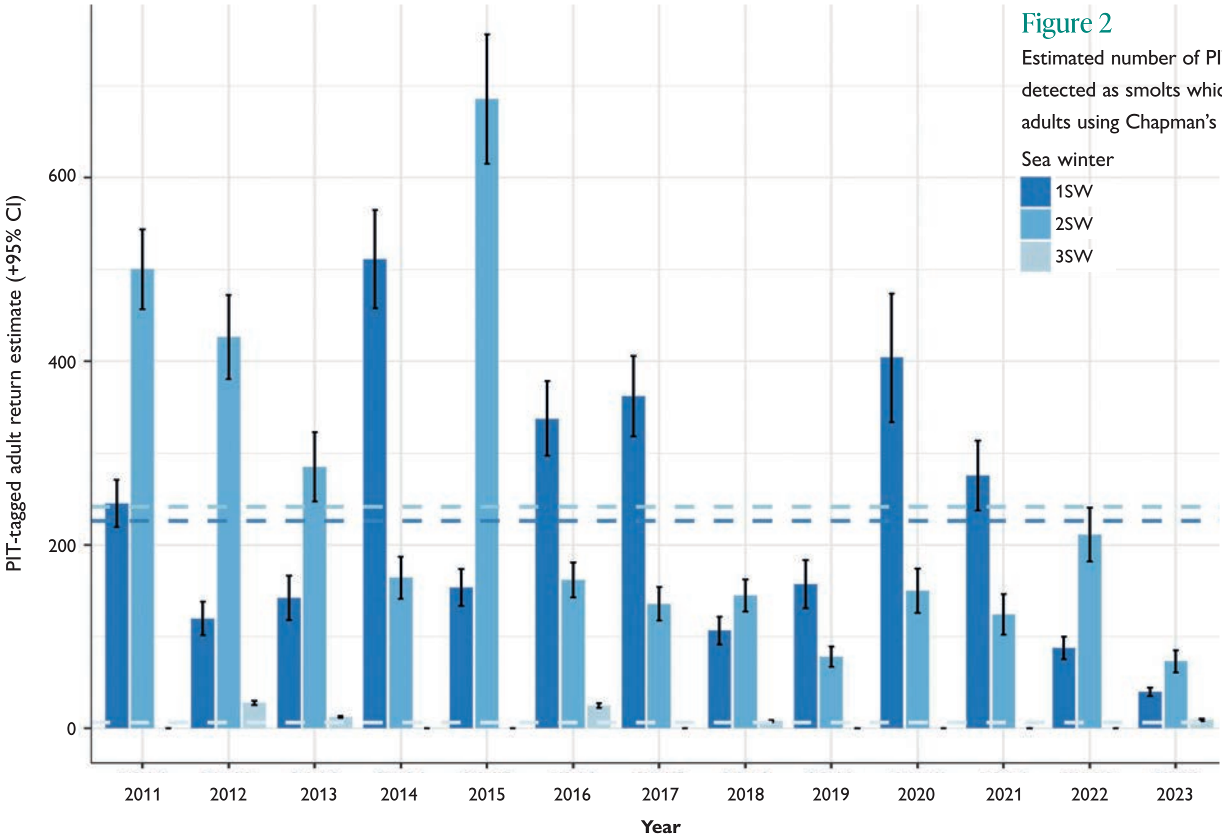


Figure 2

Estimated number of PIT-tagged parr detected as smolts which return as adults using Chapman's estimator

TABLE 2											
Estimated PIT-tagged return rate of wild salmon smolts (%) to the River Frome per sea winter cohort											
Smolt cohort	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
1SW	2.42	3.43	1.56	4.93	3.47	2.30	1.32	4.18	2.14	1.33	0.36	2.49
2SW	2.79	4.61	1.64	1.98	1.39	1.69	1.26	1.29	1.64	1.11		1.94
3SW		0.17		0.12					0.07			0.12

The estimated salmon parr in the River Frome catchment in September 2023 was 50% above the 10-year average

Figure 3

Estimated number of salmon parr in the Frome catchment in September with 95% confidence intervals (2005-2023)

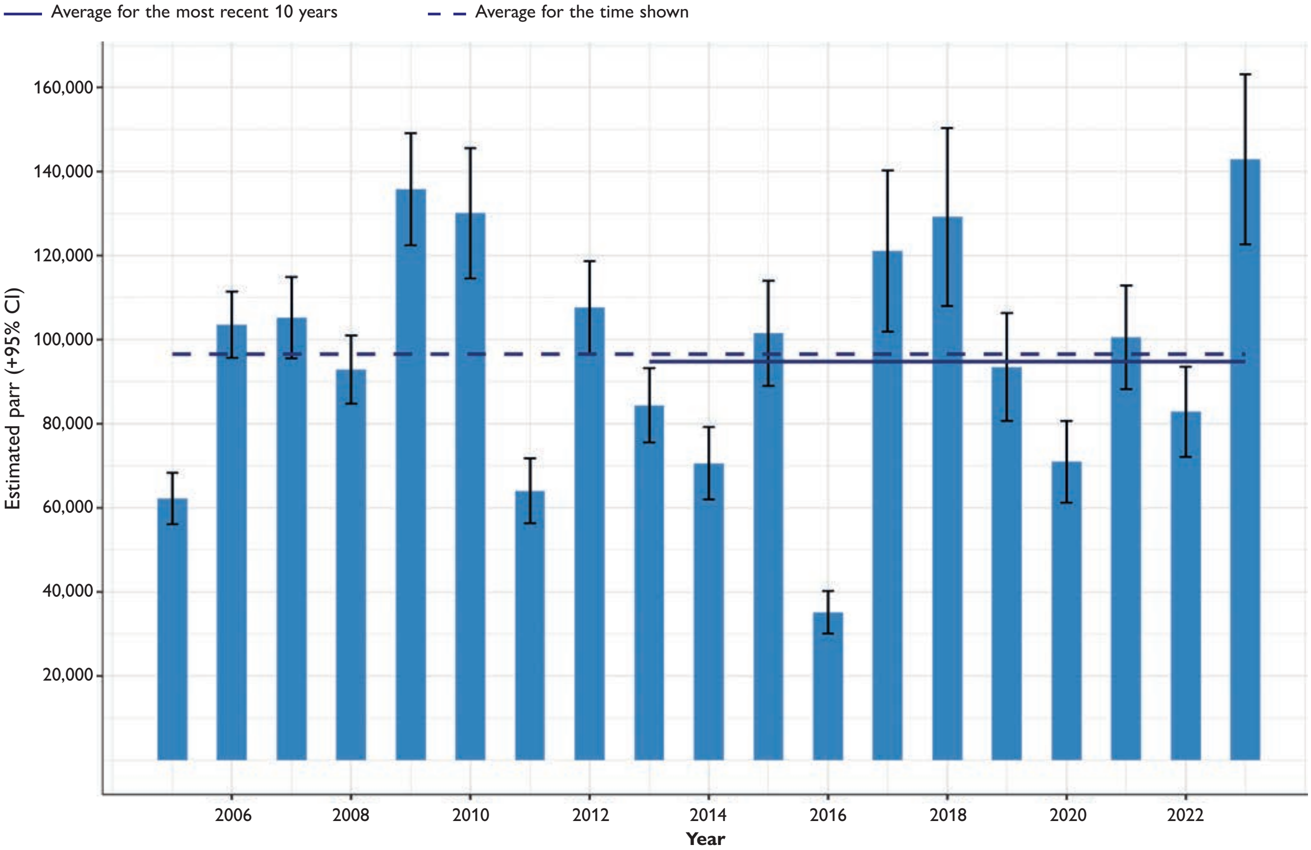
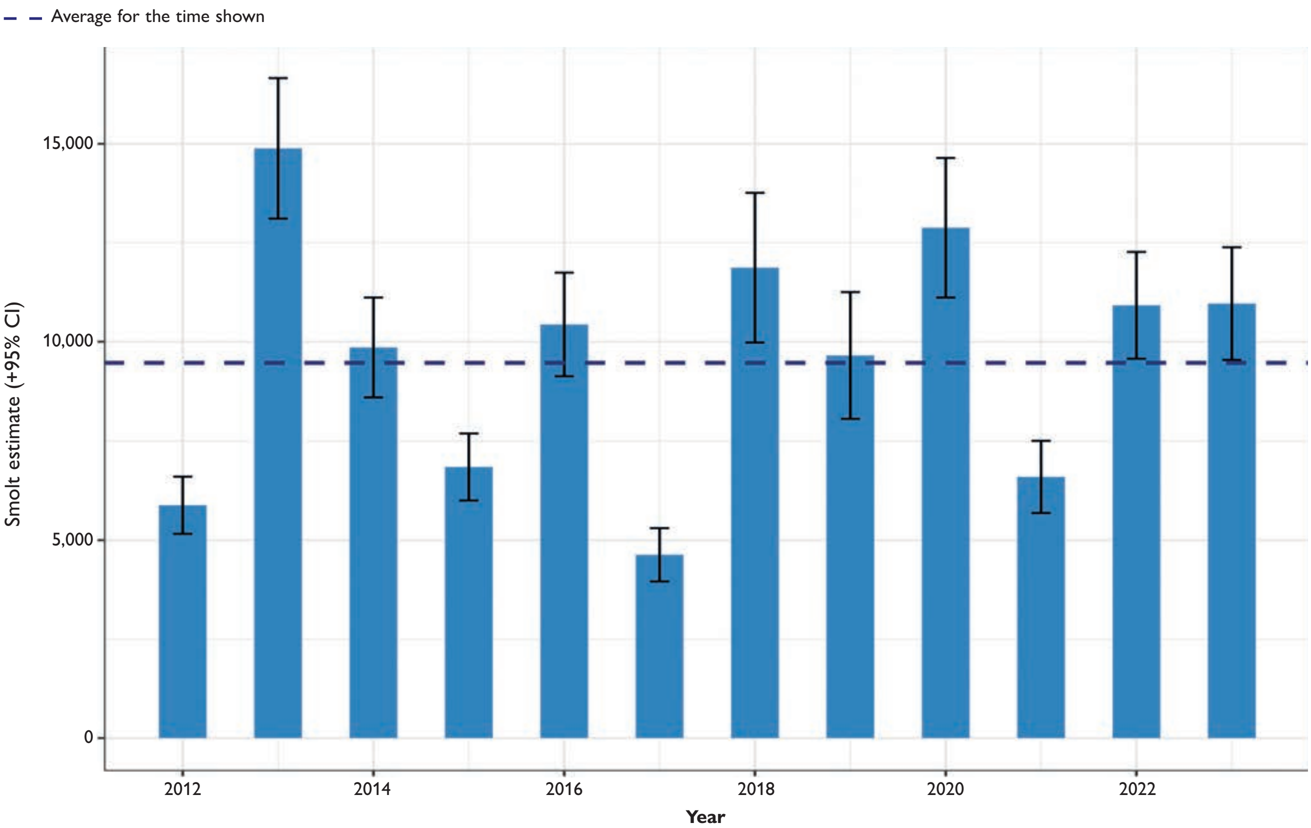


Figure 4

Estimated spring smolt population with 95% confidence intervals between 2012-2023



PIT-tag antenna readers are installed on the River Frome at four locations and the bubble curtain helps guide fish over the readers.

2. Introduction

A resistivity fish counter has monitored the upstream movement of wild adult Atlantic salmon on the River Frome since 1973. As such, the River Frome has one of the most comprehensive, long-term records of salmon spawning migrations in Europe.

The resistivity counter enables population estimates to be calculated as well as adult migration timing, which we relate to environmental factors (eg. discharge, temperature etc). Data from the counter also provides estimates of adult fish length for individuals captured by the video, which informs us of changing patterns in marine growth and the migration timing of different sizes of fish. Since adult salmon monitoring started in the 1970s, extensive research infrastructure has been established within the River Frome catchment (see Figure 5), including data loggers for monitoring environmental parameters such as temperature, turbidity, and discharge, as well as a smolt trap.

In 2002 full river coverage PIT-tag readers were installed at East Stoke on the River Frome. These antennae, in conjunction with the annual parr tagging, enable us to estimate the numbers of juveniles in the catchment, smolt migration, and adult returns (eg. Gregory et al., 2017). As the PIT-tags are individual identifiers, the PIT-tag antennae also enable us to study individual life histories and relate them to changing environmental and river conditions (eg. Gregory et al., 2019; Simmons et al., 2020; 2021). In 2014 the PIT-tag antennae at East Stoke were upgraded, and a further three sites in the catchment were either equipped with or augmented with new PIT-tag antennae (see Figure 6).

The combination of the adult resistivity 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 adult counter data gives us a long-term view of spawning migration timing, which can be related to dependence on environmental conditions. The PIT-tag data enables us to understand the critical mortality phases of salmon, together with the freshwater factors that affect mortality and life history patterns. From a management perspective, the ability to quantify both smolt production and returning adults enables us to analyse loss rates in freshwater and at sea separately.

Figure 5

Site plan of the monitoring equipment in the River Frome at East Stoke

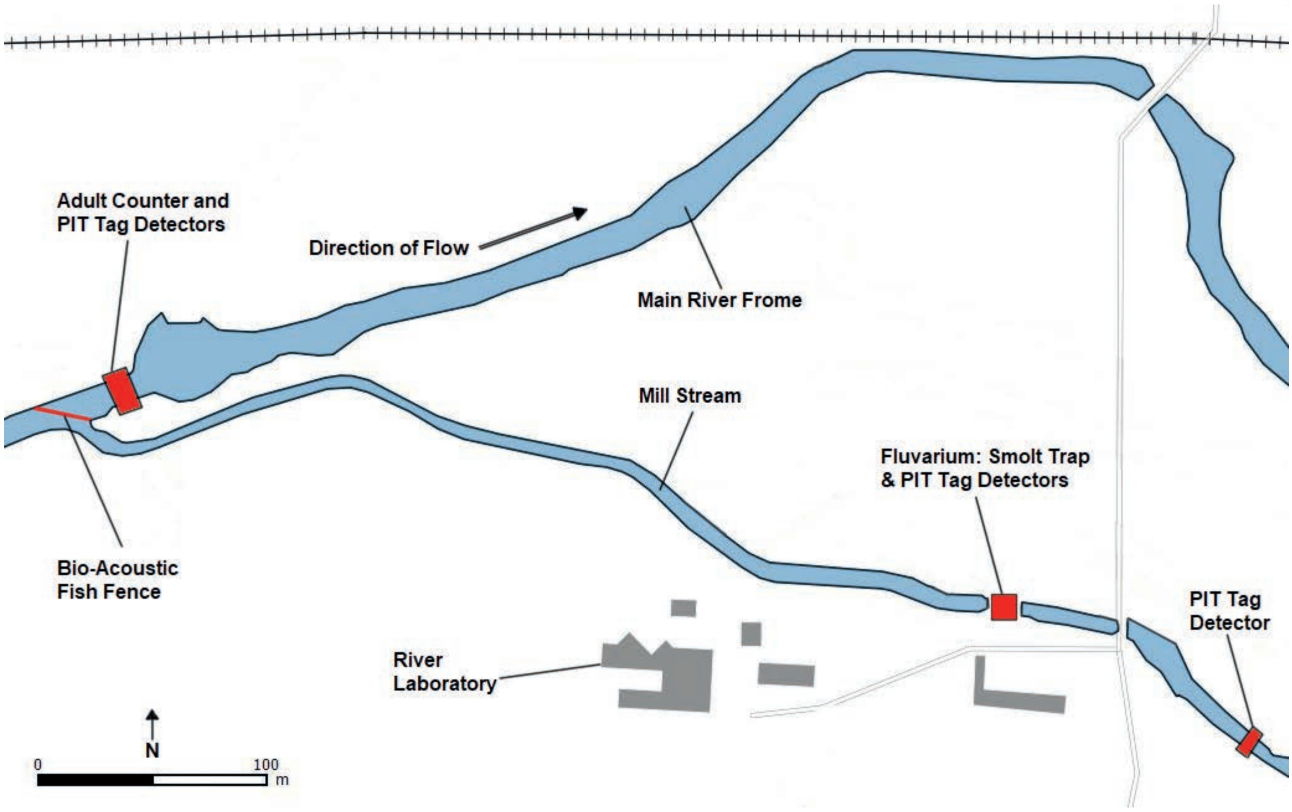
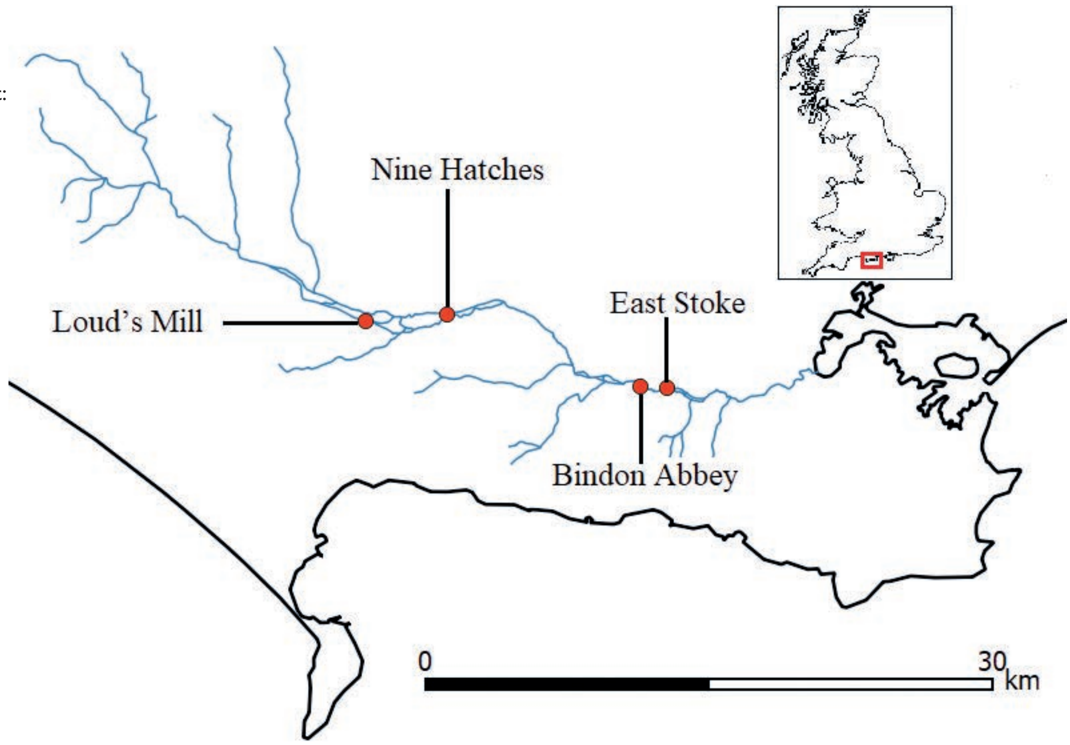


Figure 6

Location of PIT-tag antennae in the River Frome catchment: East Stoke; Bindon Abbey; Nine Hatches and Loud's Mill



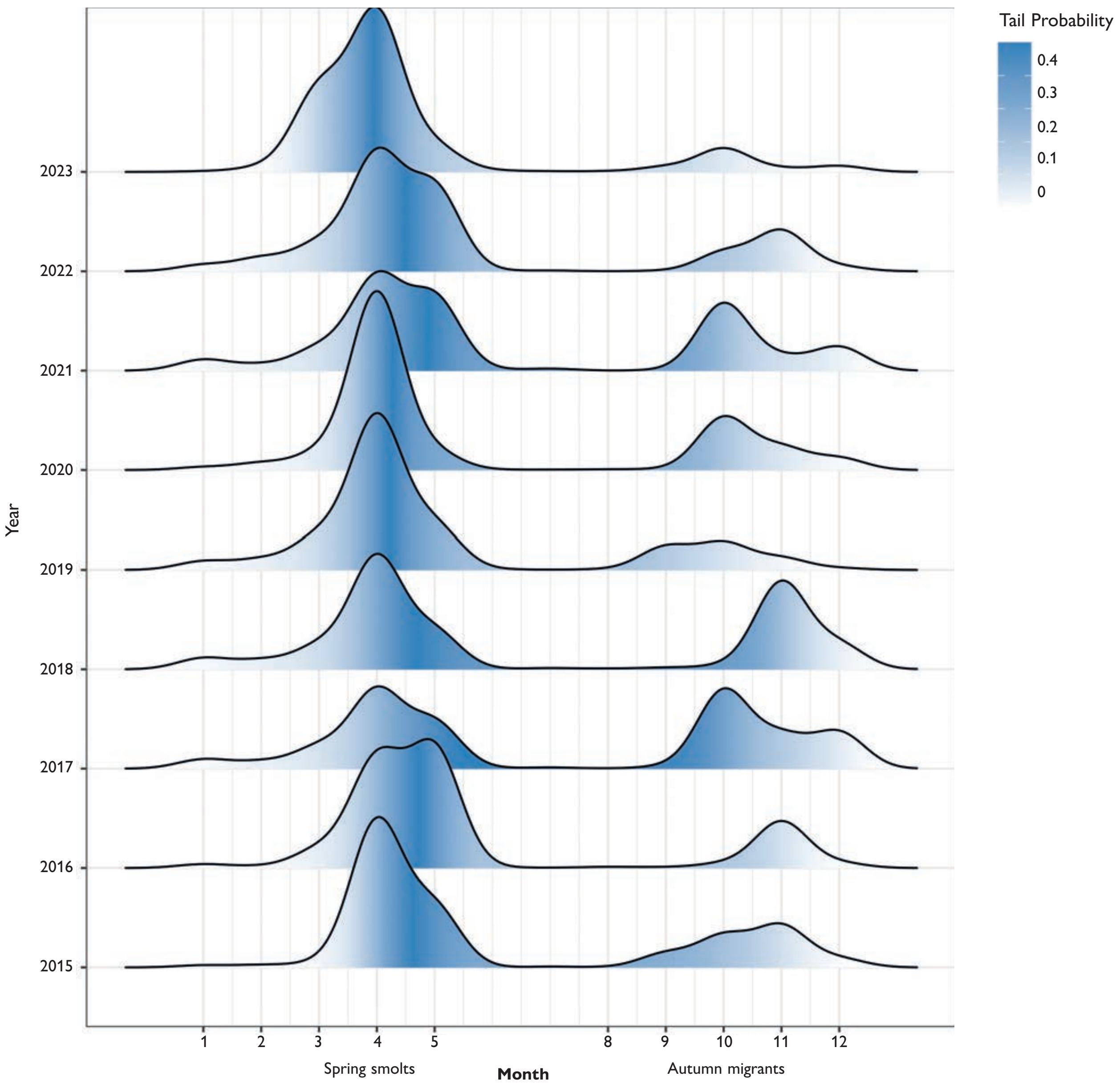
Juvenile movement patterns

In mid-March 2023 we installed a new Wolf trap at East Stoke to capture smolts in spring. This replaced the much less efficient Rotary Screw Trap (RST). The Wolf trap is a system of grids that filter the migrating smolts from the water as they swim downstream. Wolf traps are highly efficient and we have found that it catches almost 100% of the fish that are deflected down the Millstream by the bubble screen regardless of river levels. The RST was only between ~40 to ~65% efficient in low and high flows respectively. This enables us to collect consistently more salmonids.

A feature of the PIT-tag antennae is that they operate 24/7 all year, hence the detection data from the PIT-tag antennae provide detailed information on movement patterns throughout the year and not just in the perceived migration periods. Not long after installing our first PIT-tag antennae at East Stoke, we realised that significant downstream movement of juvenile salmon occurs during autumn and early winter in the River Frome (see Figure 7). Although this phenomenon had been reported before, the subsequent migration and life-history choices of juvenile salmon are less well understood. A study we undertook previously on autumn migrants, indicated that this movement is an active decision to move downstream (ie. the fish are not just passively drifting downstream; Pinder et al., 2007; Ibbotson et al., 2012). However, since the fish have not developed the ability to tolerate salt water in the autumn, we found that many of the fish overwinter in the lower river well into the freshwater part of the tidal zone downstream of Wareham. From the PIT-tag data, we have since recorded many returning adults who were autumn migrants, so we know that these fish do survive and contribute to the adult spawning population. During the 2023 smolt year, 33% of PIT-tagged juveniles migrated outside of the smolt season and 67% smolted in spring 2023 (see Figure 7).

Figure 7

The density distribution of smolt migration over the year and changes between years (2015-2023), providing the proportion of migrating smolt over the year with tail probabilities indicating areas of lower variance. The first set of peaks per year indicate spring smolts and the second set, autumn migrants from the same smolt year



3. Results

Autumn parr estimate

From the number of parr PIT-tagged in autumn (August to September) and the ratio of tagged to untagged smolts caught in the smolt trap the following spring (April to May this year as a result of excessively high river levels), estimates of the number of salmon parr in the catchment at the time of tagging are made. The estimate for autumn 2023 is 142,908 (95% Confidence Intervals (CI) 20,204). This is 50% above the 10-year average (94,830; see Figure 3), as opposed to 2022, where the parr estimate was 7% below average (82,846 ± 10,718 95% CI).

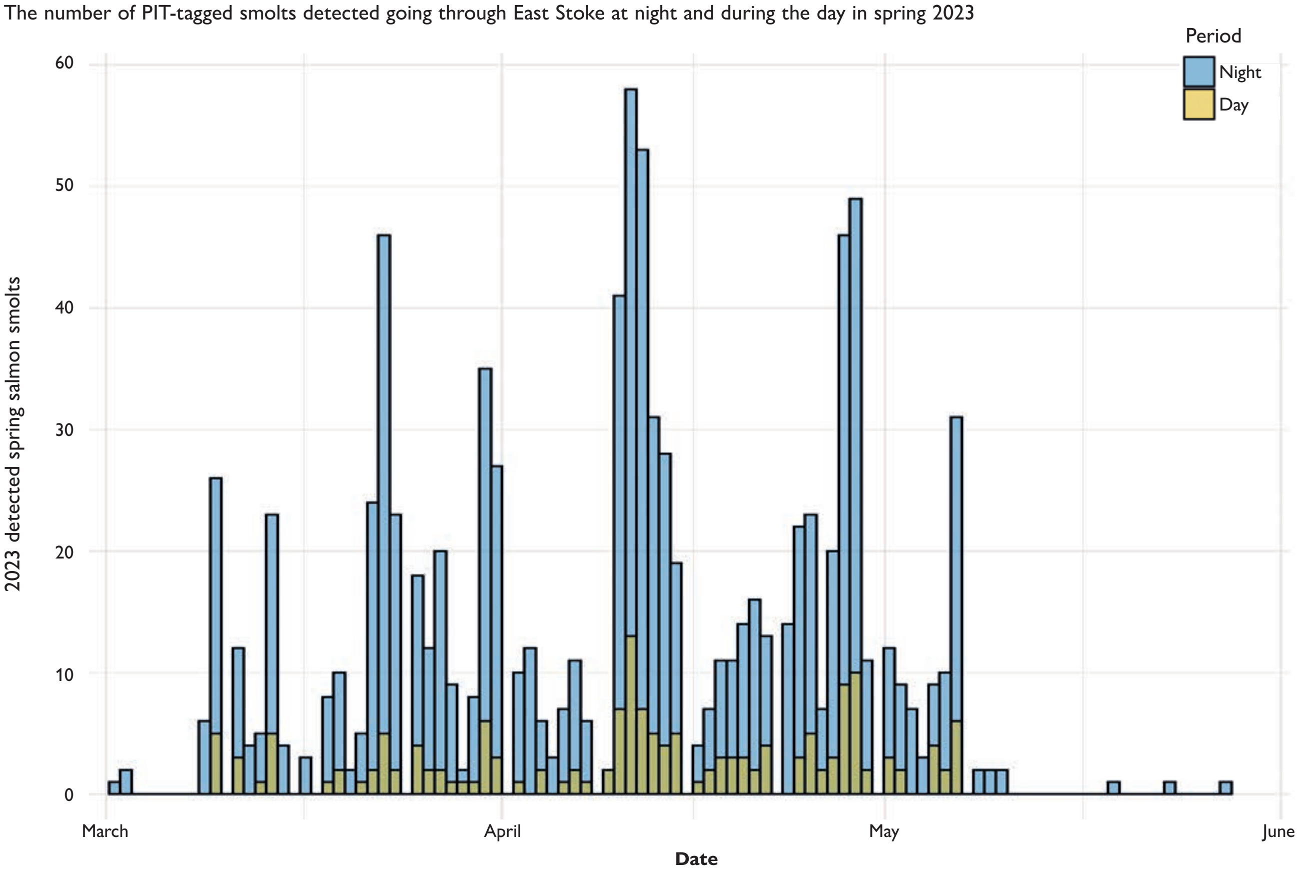
Smolt estimate

The day/night detection pattern of salmon smolts at East Stoke during 2023 is shown in Figure 8. The peak of the smolt migration took place in mid-April during a heavy discharge period (see Figure 8; Simmons et al., 2021). Fourteen percent of the tagged smolts were detected moving during the daytime, which is in line with other years (15%).

The estimated number of salmon smolts at East Stoke in 2023 was 10,963 with a confidence interval of ± 1,423 (see Figure 4). This is 16% above the 10-year average (9,465), hence we are expecting a good adult run in 2024 and/or 2025 (depending on the ratio of 1SW to 2SW) from this 2023 smolt cohort, if marine survival remains stable.

Figure 8

The number of PIT-tagged smolts detected going through East Stoke at night and during the day in spring 2023



Adult estimate

In late 2021 new electronics for the Resistivity Counter were installed, since the old system had been in place for more than 30 years. This new Counter was donated by the Environment Agency (EA), allowing the River Frome to benefit from what will become the default counting system for the EA-monitored counter network. Since the new system has been installed there have been no days without waveform data providing information on fish migration (see page 16 for methods). Daily gross upstream and downstream counts together with mean daily discharge are shown in Figure 9. Table 3 shows monthly data from the counter and gives gross upstream and gross downstream counts as well as the nett upstream estimate.

The total annual estimate from the counter of 443 salmon which is 22% below the 10-year average (569; see Figure 1; Figure 10). Table 1 for 2023 shows that there was a strong and early run of salmon. However, the number of returning adults was a lot lower than the 10-year average for the second half of the year (see Table 1).

Despite an above average smolt cohort for 2022 (see Figure 4), the number of 1SW salmon recorded was well below average in 2023 (see Table 2; Figure 2). In the last few years (2022 and 2023), an increase in 2SW returning adults has been observed relative to 1SW (see Figure 2 and Table 2). These 2SW salmon primarily originate from the 2020 and 2021 smolt cohort and although the 2021 smolt cohort was low (see Figure 4) there appears to be a switch to increasing MSW returning salmon. Since a high proportion of the 2SW salmon are female (Trehin et al., 2021) and, as the number of eggs per female is strongly related to body size, we hope this will result in an above-average egg deposition in 2024 and 2025 from 2SW returning adults from the strong 2022 and 2023 smolt cohort, if marine mortality remains minimal.

Figure 9

Daily gross up-stream (green bars) and downstream (orange bars) counts for 2023 and the associated daily mean river discharge (blue line)

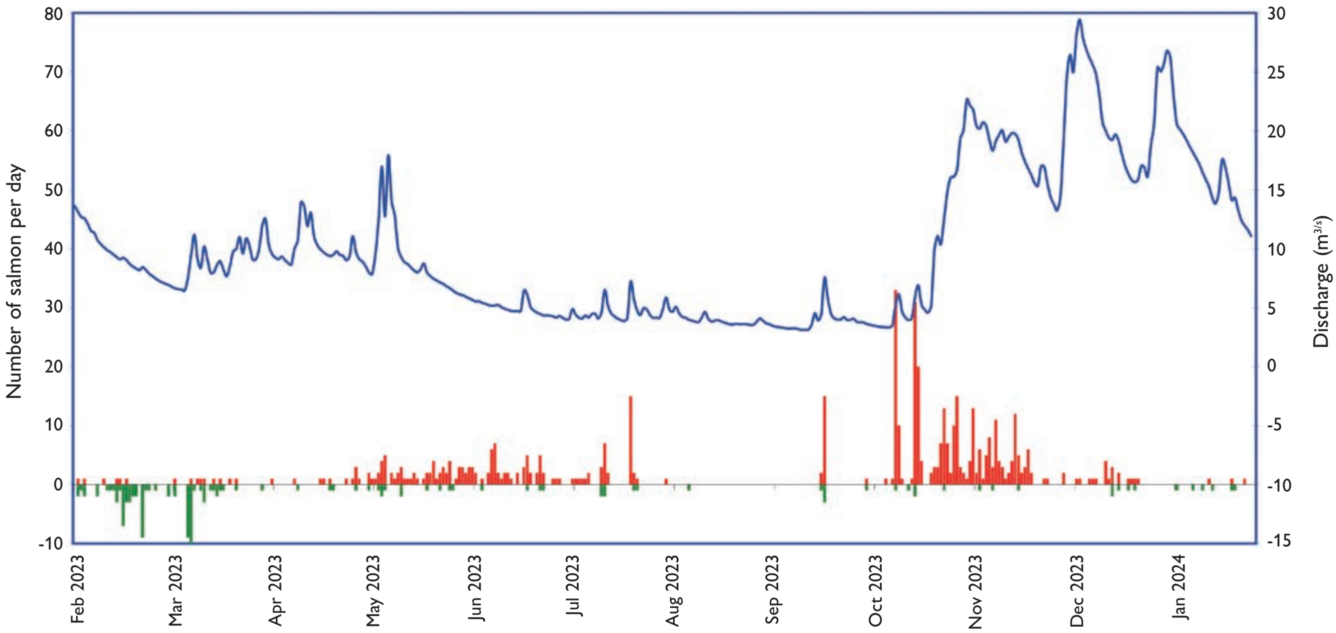


TABLE 3

Monthly movement of returning adults measured by the counter and tracer

2023	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '24	Total
Gross U/S	6	9	11	54	60	38	1	17	150	120	21	3	**490**
Gross D/S			4	11	4	6	1	4	6	3	5		**44**
Nett U/S	3	9	7	43	56	32	0	13	144	117	16	3	**443**

Data corrected for kelts

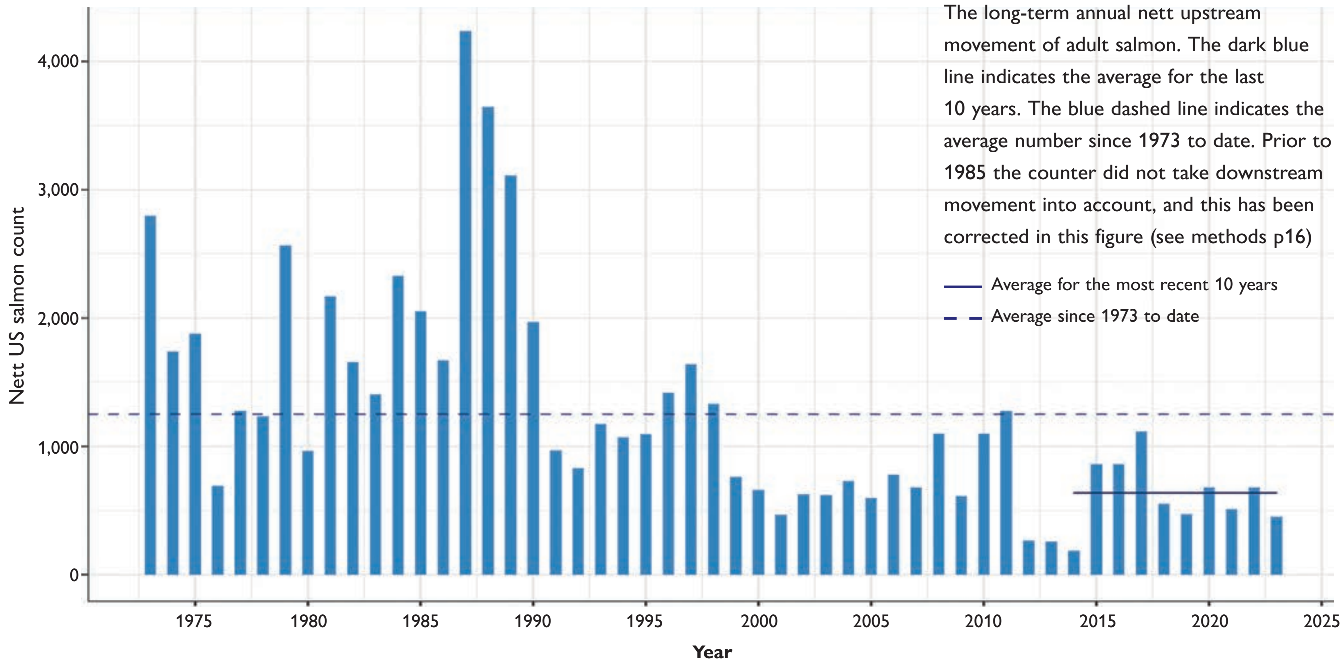


Figure 10

The long-term annual nett upstream movement of adult salmon. The dark blue line indicates the average for the last 10 years. The blue dashed line indicates the average number since 1973 to date. Prior to 1985 the counter did not take downstream movement into account, and this has been corrected in this figure (see methods p16)

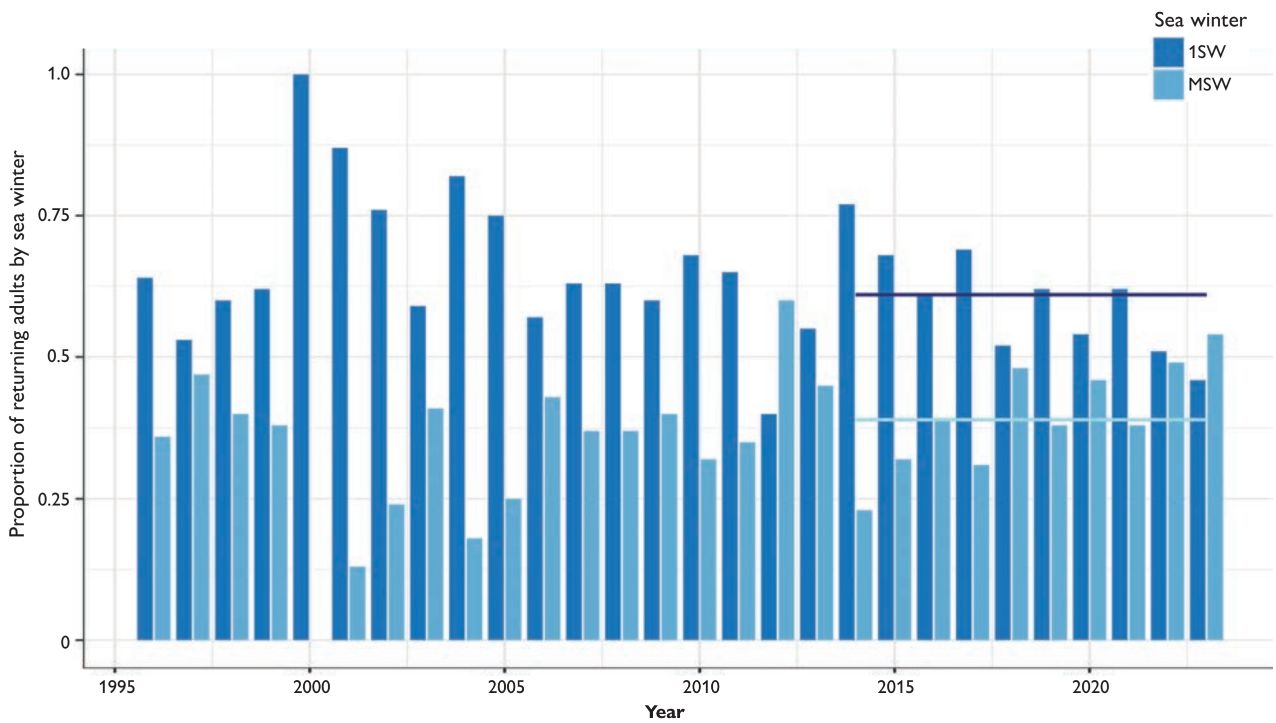
Average for the most recent 10 years
Average since 1973 to date

Fish size and sea age

Due to poor water visibility from high rains, the video images recorded at the fish counter enabled us to estimate the length of just 108 (23%) adults registered on the counter in 2023. The largest 2023 salmon recorded was 116cm with a mean MSW size of 86cm (SD 6cm), whereas the 2023 grilse mean size was 61cm (SD 5cm). The 10-year average for MSW salmon is 83cm (2.5 SD), and 60cm with a 0.5 SD for grilse. Based on the 103 adults where we estimated length from the video image, 46% of the 2023 run were 1SW salmon, and 54% were MSW salmon (see Figure 11). This is below the 10-year average of 60% 1SW fish but greater than the 10-year average (40%) MSW fish.

Figure 11

The annual proportion of 1SW and MSW salmon detected from video images over the resistivity counter. The light blue line indicates the average proportion of MSW salmon detected in the last 10 years and the dark blue line indicates the average proportion of 1SW salmon detected



Conservation limit

The conservation limit for the River Frome is the deposition of 1.5 million eggs (the very minimum number of salmon eggs required to ensure a viable population as estimated by the Environment Agency) and in 2023 the egg deposition estimate calculated by the Environment Agency was 1.35 million eggs based on the adult run estimate from the resistivity counter, the size distribution and sea age of returning salmon, and potential natural and fishing mortality. The estimate for 2023 is therefore only 89.9% of its conservation limit (see Figure 12). The 10-year average for the River Frome is 121.89% of its conservation limit, with only three years falling below the conservation limit in this 10-year period.

River discharge

For 2023 the River Frome discharge at East Stoke was above 1966 to 2022 quartiles and extreme 5th percentile at the outset and the end of the year indicating a wetter than average year (see Figure 13).

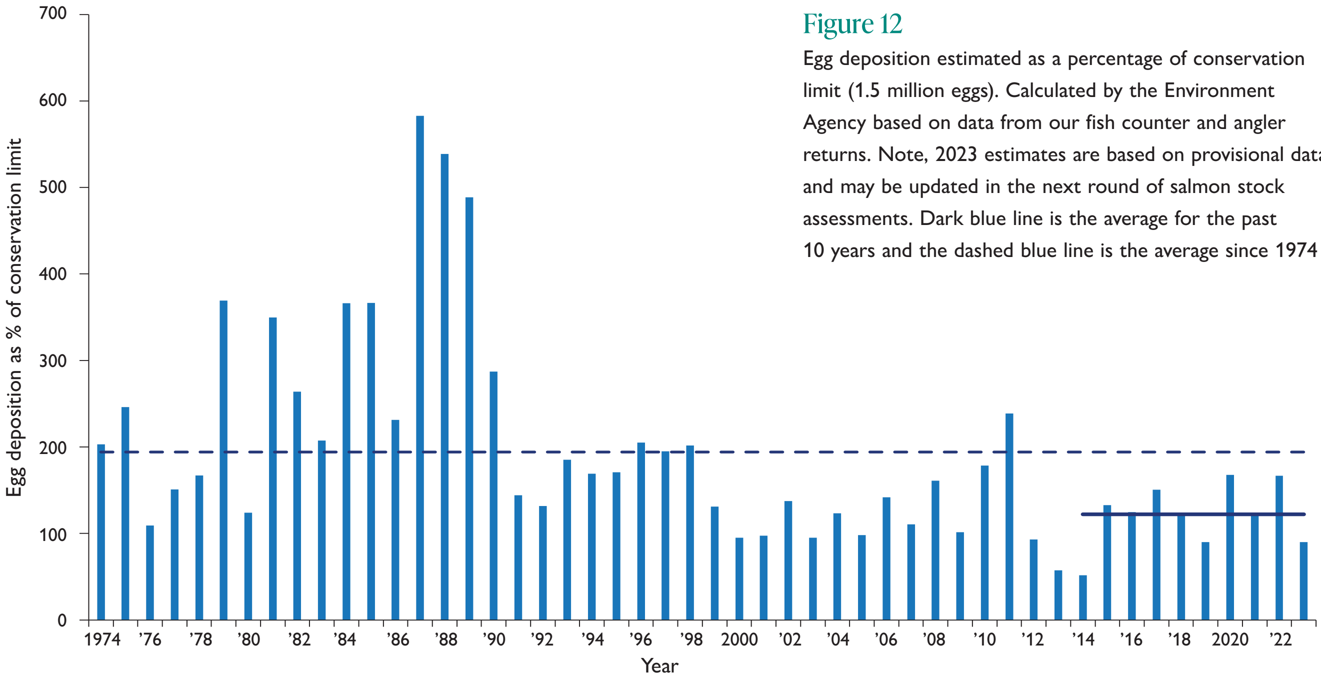
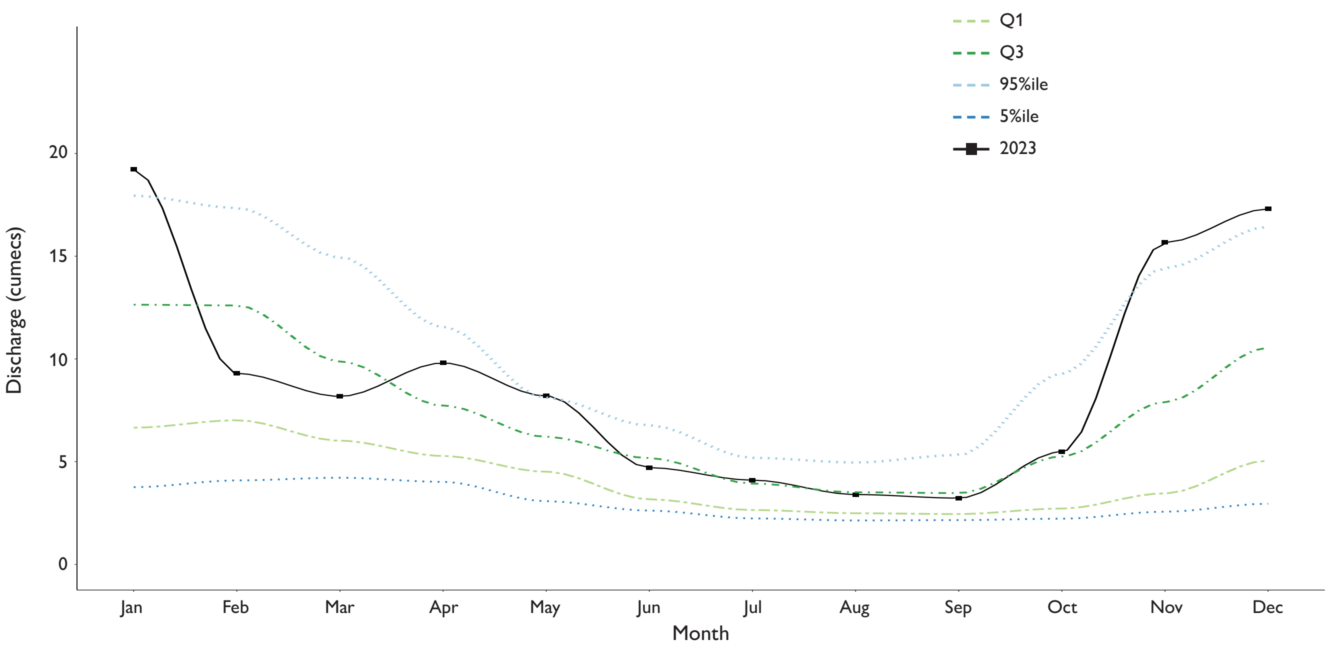


Figure 12

Egg deposition estimated as a percentage of conservation limit (1.5 million eggs). Calculated by the Environment Agency based on data from our fish counter and angler returns. Note, 2023 estimates are based on provisional data and may be updated in the next round of salmon stock assessments. Dark blue line is the average for the past 10 years and the dashed blue line is the average since 1974

Figure 13

Mean monthly discharge data (in cubic metres per second (cumecs)) for 2023 relative to the long-term average 5 percentile (5%ile), 25%ile (Q1), 75%ile (Q3) and 95%ile discharge data for the period 1966-2022. Values represent the proportion of time that discharge has historically been above the stated value (ie. for the 95%ile, values have only been above this level for 5% of the time and for 5%ile, discharge was above this value for 95% of the time (since 1966)). The data are collated and calculated from Environment Agency records




BRUTE

4. Methods

This section has been written to reflect the long-term methods used to survey salmon on the River Frome and as such should not vary from one year to the next.

Parr tagging

In September, since 2005, we electric-fish and mark approximately 10,000 juvenile salmon (8-15% of the juvenile salmon population in the catchment) with 12mm full duplex PIT-tags. PIT-tagging sites are spread throughout the catchment upstream of East Stoke. During the tagging process, we also record length, weight, and take a scale sample of each individual, before returning them to the same 100 metre reach from where they were captured. We also remove the adipose fin (the small fin behind the dorsal fin) so that we, and other fishery surveys, can identify tagged fish when they are recaptured. The PIT-tags (12mm long x 2mm in diameter; see Figure 14) are inserted into the peritoneal cavity of the parr and enable us to identify individual fish when they swim past our detector antennae. Nearly all PIT-tags will stay with the fish until at least their first spawning. Passage of tagged fish out to sea, and fish returning from the sea, are recorded by the PIT-tag antennae installed throughout the catchment (see Figure 6).

Catchment parr estimate

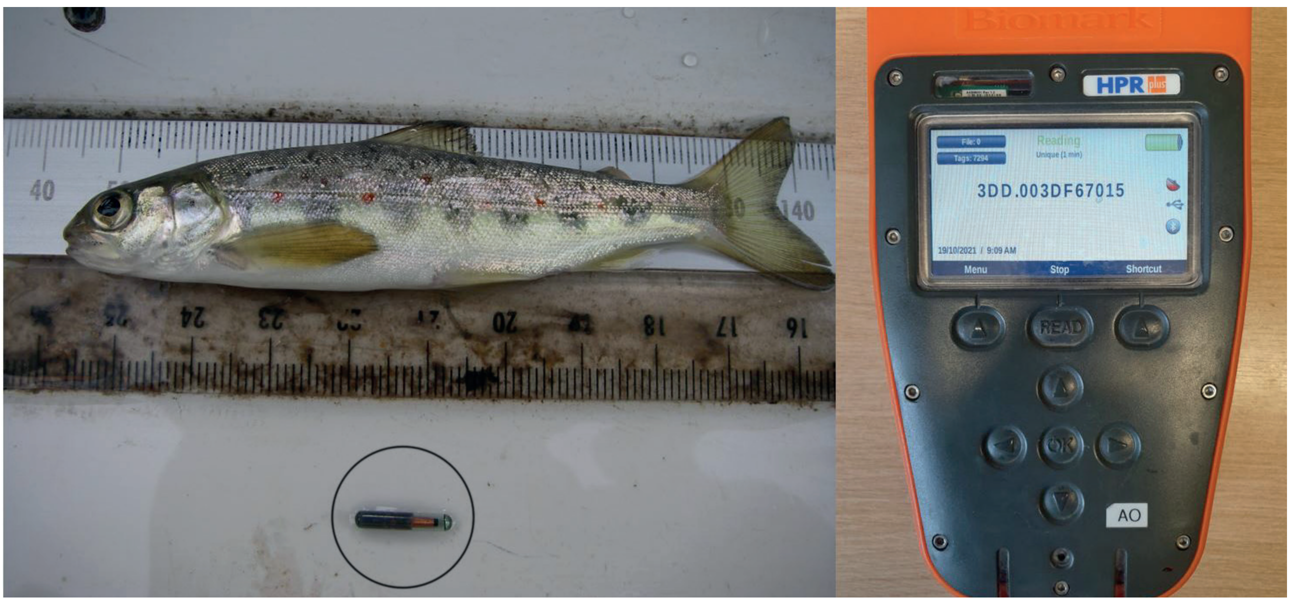
Trying to estimate the total number of parr in a whole catchment is difficult. However, it is possible to estimate population numbers (see Figure 3) by marking some of the population and then sampling that population later to see what proportions are marked. On the River Frome, we use a variation of this method to determine the number of both autumn parr and smolts in the catchment. To estimate the number of parr during autumn tagging we divide the number of parr tagged in the autumn with the proportion of the population that is tagged in the following spring. We obtain a measure of the proportion of the population that is tagged by quantifying the proportion of tagged to non-tagged smolts captured in our smolt trap at East Stoke the following spring.

Smolt estimate

We have estimated the number of smolts emigrating from the river since 1995. Since 1996 we have used a BAFF to divert the smolts down the Millstream at East Stoke, where we have our smolt trap. However, as a result of the unknown efficiency of the main river antenna (next to the Counter), we have used detections from the Bindon antenna (set up in 2012) to estimate the main river antenna, including a survival parameter between Bindon and East Stoke which has a distance of approximately 2.8km (see Figure 4). More accurate smolt estimates have therefore been made since 2012. From detections of PIT-tags in the Millstream and on the main river downstream of the BAFF, we know that deflection efficiency is good, operating at up to ~80%. In the Millstream, the smolts pass through the Fluvarium channels where PIT-tag antennae detect the tagged smolts. On leaving the Fluvarium they encounter the Wolf trap (prior to 2023 the Rotary Screw Trap (RST)) where a proportion of the smolts migrating down the Millstream are intercepted.

Figure 14

Salmon parr and PIT-tag (circled). During tagging the PIT-tags are scanned by a reader and their individual IDs are stored against information on tagging location and fish biometrics



In most years the BAFF and the RST/Wolf trap are operational from the 25th of March until the smolt run ends sometime in early to mid-May. The trap is operated most days throughout the trapping season with a day and night shift. When in operation, we check and empty the RST every 30 minutes. Biometrics of all intercepted smolts are recorded and we take a scale sample of a stratified subset of smolts. Smolts without an adipose fin have their PIT-tag scanned before recording biometrics and taking a scale sample. After processing, all intercepted smolts are released downstream of the trap.

The smolt estimate is derived from the number of PIT-tagged smolts detected at East Stoke during the smolt run window (1st of March to the 31st of May), the efficiency of the PIT-tag antennae (calculated from multiple antennae), a survival parameter between Bindon and East Stoke, and the proportion of PIT-tagged smolts among the ones intercepted by the smolt trap.

Adult estimate from the resistivity counter

The resistivity counter at East Stoke has been recording fish movement since 1973, and over the years the counter has been operated by several organisations: Freshwater Biological Association (1973-1989), Institute of Freshwater Ecology (1989-2000), and Centre for Ecology & Hydrology (2000-2009). In April 2009, the GWCT took over the running of the counter at East Stoke.

Currently, data is collected by the EA's Conductance sensor resistivity counter connected to three stainless steel electrodes mounted 45cm apart on the EA venturi gauging weir at East Stoke (NGR SY 867868). The counter works by constantly measuring the electrical resistance of the water. When a fish of sufficient size (larger than 45cm) passes over the electrodes the electrical resistance changes, which is registered as an event on the counter (see Figure 15).

Adult salmon data is presented for the period from the 1st of February to the 31st of January the following year. Past data and video observations indicate that most of the upstream movement of salmon on the River Frome in January are spawning fish, and not fish from a new cohort that will be spawning later that year. Data is collected for both gross up-

Figure 16

Change in electrical resistance of the water recorded by the trace computer during the event of an upstream migrating salmon

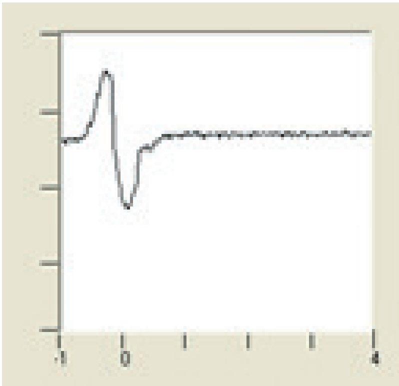


Figure 15

Screen display from the computerised video verification system. The image shows a 78cm salmon ascending the weir

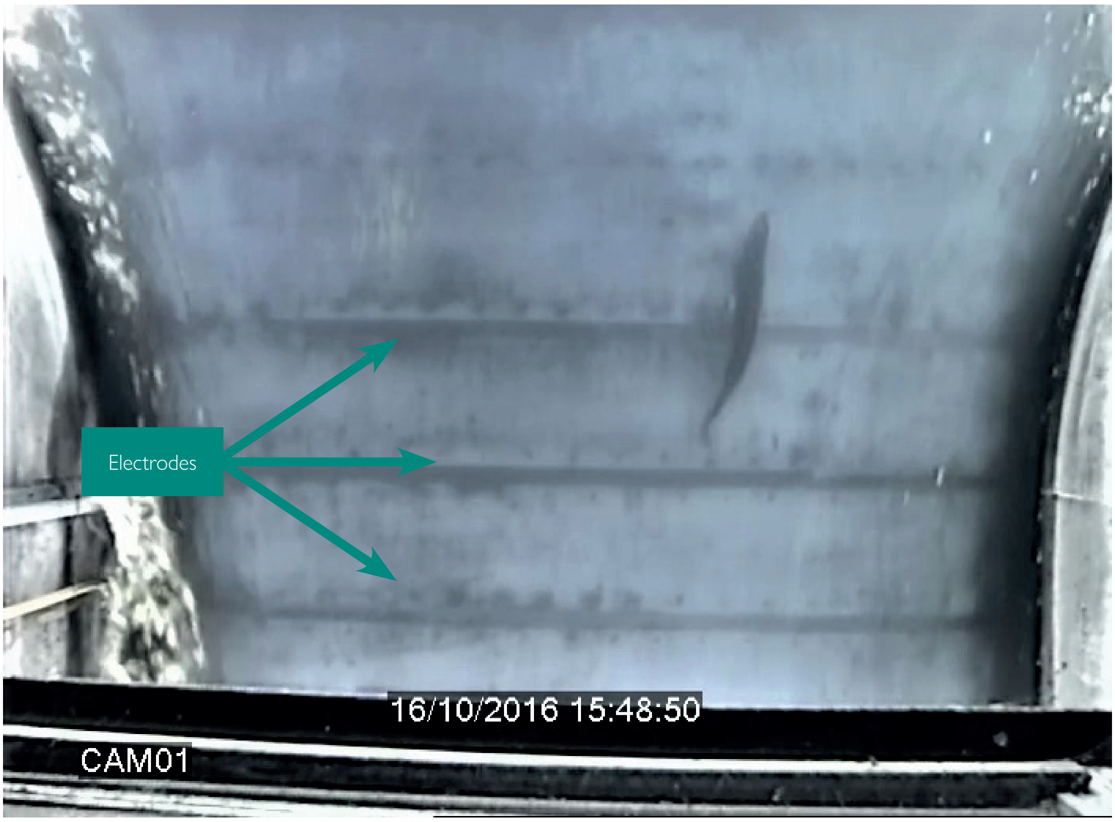


Figure 17
Two Atlantic salmon smolts of contrasting sizes

and down-stream events. The gross upstream number is the total number of fish moving upstream over the weir and the nett upstream number is the gross upstream number minus the gross downstream number. However, during January, February, and March the downstream counts are not subtracted from the upstream numbers as a high percentage are caused by downstream moving kelts (post-spawning individuals). Some kelts, however, carry out repeated up and down movement over the weir, and if down-numbers are not subtracted this can lead to over-estimating the number of upstream migrating fish. Therefore, where up counts have been caused by kelts, these are subtracted from the totals.

Until 1984, only gross upstream events were collected. These gross upstream numbers for the early years have since been adjusted by the relationship between nett and gross upstream numbers from subsequent years so that the presented data represents a nett upstream estimate.

Data verification

To ensure that the data collected from the resistivity counter is ecologically meaningful each recorded event must be verified and at GWCT large resources are allocated to verify the data from the East Stoke resistivity counter. The data from the resistivity counter is verified by a combination of computer trace analysis (change in electrical resistance) and digital video image analysis.

Raw data events recorded by the resistivity counter are verified by first assessing the shape and magnitude of the waveform trace generated by the computer interpretation of the change in resistance of the water (see Figure 16) followed by viewing the corresponding video records (see Figure 15). In 2016 we upgraded our Video Home System (VHS) to a Digital Video Recorder (DVR) timelapse that allows us to store all the images we record from the counter.

There can be multiple reasons for triggering a raw data event (eg. salmon, sea trout, other fish, or anything more conductive than the water), so using the two above methods enables us to assign each event to a category. For example, during periods when the computer trace data isn't operational, counts are assessed by direct examination of the video records, whereas the event evaluation is based on the trace signal analysis only during periods when the turbidity is too great to use the video records.

Assigning sea age contribution to adult run

We use the video images of upstream migrating fish to estimate their length (see Figure 16). These length estimates are used to estimate the proportion of 1SW and MSW salmon among the upstream records (see Figure 11). We are unable to record the length of all adults as migration, especially in the autumn, coincides with high turbidity. Historically, we used 74cm as the upper size limit of returning 1SW salmon. However, in recent years we, and other researchers (Trehin et al., 2021), have observed that the minimum length of returning adult salmon appears to be getting smaller. As a result, we adjusted the upper size limit of 1SW salmon to 72cm in 2018 and since 2014 we have included data from fish (identified as salmon) larger than 45cm whereas in earlier years only fish larger than 49cm were included. We are continuously assessing the upper size limit of 1SW fish from the scales of returning salmon.

Conservation limit

The EA produces an egg deposition estimate for all the 49 principal salmon rivers in England. This egg deposition estimate is based on the estimated number of salmon returning to the individual rivers, their sea age distribution, and the proportion of females. For most rivers this information is deduced from declared angling catches but on the River Frome, and other rivers with fish counters or adult traps, the calculation is based on the fish counter/trap data. The egg deposition estimate is used to evaluate if the salmon stock in the river is reaching its conservation limit or not. The conservation limit for the River Frome is set at 1.5 million eggs.

Marine return rates

We have reported the marine return rates to the International Council for the Exploration of the Sea (ICES) since we first started quantifying the number of emigrating smolts. In the early years, this was based on our smolt estimate and adult return estimates from the resistivity counter. However, since the installation of our first PIT-tag antennae (see Figure 18) at Bindon Abbey in 2012, the marine return rates have been estimated from the detection of PIT-tagged adults. The total number of returning PIT-tagged fish is estimated using a mark-recapture calculation from detections made at East Stoke and then Bindon Abbey. To estimate the total number of returning adults, the estimate of returning PIT-tagged adults is divided by the proportion of tagged smolts in the given smolt cohort based on data from the RST.

Collection of environmental data

In conjunction with data on the salmon population, water temperature, water turbidity, air temperature, and light levels are also collected at 15-minute intervals from purpose-built instrumentation at East Stoke.

Figure 18

Floating PIT-tag antennae are part of the PIT-tag systems on the River Frome at East Stoke

Game & Wildlife CONSERVATION TRUST

THE MISSING SALMON ALLIANCE

Acknowledgements

We would like to thank the Environment Agency for its financial support to the data collection, Cefas for its continued contribution to the River Frome PIT-tagging programme, and the SAMARCH project which is part-funded through the EU's Interreg Channel VA Programme. We would also like to thank organisations previously in charge of running the resistivity counter for the use of the early data and all the land and fisheries owners in the catchment for giving us access to their land enabling our work to continue.

5. References

1. **Gregory, S.D.**, **Ibbotson, A.T.**, Riley, W.D., Nevoux, M., **Lauridsen, R.B.**, Russell, I.C., Britton, J.R., Gillingham, P.K., **Simmons, O.M.**, Rivot, E., & Durif, C. (2019). Atlantic salmon return rate increases with smolt length. *ICES Journal of Marine Science*, 76(6), 1702-1712. https://doi.org/10.1093/icesjms/fsz066.

2. **Gregory, S.D.**, Nevoux, M., Riley, W.D., **Beaumont, W.R.C.**, Jeannot, N., **Lauridsen, R.B.**, Marchand, F., **Scott, L.J.**, & Roussel, J.-M. (2017). Patterns on a parr: Drivers of long-term salmon parr length in U.K. and French rivers depend on geographical scale. *Freshwater Biology,* 62(7), 1117-1129. https://doi.org/10.1111/fwb.12929.

3. **Ibbotson, A.T.**, Riley, W.D., **Beaumont, W.R.C.**, Cook, A.C., Ives, M.J., Pinder, A.C., & **Scott, L.J.** (2012). The source of autumn and spring downstream migrating juvenile Atlantic salmon in a small lowland river. *Ecology of Freshwater Fish*, 22, 73-81. https://doi.org/10.1111/eff.12003.

4. Pinder, A.C., Riley, W.D., **Ibbotson, A.T., & Beaumont, W.R. C.** (2007). Evidence for an autumn downstream migration and the subsequent estuarine residence of 0+ year juvenile Atlantic salmon *Salmo salar L*., in England. *Journal of Fish Biology*, 71, 260-264. https://doi.org/10.1111/j.1095-8649.2007.01470.x.

5. **Simmons, O.M.**, Britton, J.R., Gillingham, P.K., & **Gregory, S.D.** (2020). Influence of environmental and biological factors on the overwinter growth rate of Atlantic salmon *Salmo salar* parr in a UK chalk stream. *Ecology of Freshwater Fish*, 29(4), 665-678. https://doi.org/10.1111/eff.12542.

6. **Simmons, O.M.**, **Gregory, S.D.**, Gillingham, P.K., Riley, W.D., **Scott, L.J.**, & Britton, J.R. (2021). Biological and environmental influences on the migration phenology of Atlantic salmon *Salmo salar* smolts in a chalk stream in southern England. *Freshwater Biology*, 66(8), 1581-1594. https://doi.org/10.1111/fwb.13776.

7. Tréhin, C., Rivot, E., Lamireau, L., Meslier, L., Besnard, A.-L., **Gregory, S.D.**, & Nevoux, M. (2021). Growth during the first summer at sea modulates sex-specific maturation schedule in Atlantic salmon. *Canadian Journal of Fisheries and Aquatic Sciences*, 78(6), 659–669. https://doi.org/10.1139/cjfas-2020-0236.

6. Scientific papers

GWCT has published numerous other papers from its salmon research, references from 2023 to 2018 are below.

2023

Artero, C., Gregory, S.D., Beaumont, W.A., Josset, Q., Jeannot, N., Cole, A., Réveillac, E., & **Lauridsen, R.B.** (2023). Survival of Atlantic salmon and sea trout smolts in transitional waters. *Marine Ecology Progress Series.* https://doi.org/10.3354/meps14278.

Elliott, S.A.M., Deleys, N., Beaulaton, L., Rivot, E., & Acou, A. (2023). Fisheries-dependent and -independent data used to model the distribution of diadromous fish. *Data in Brief.* 48: 109107. DOI: 10.1016/j.dib.2023.109107.

Elliott, S.A.M., Acou, A., Beaulaton, L., Guitton, J., Réveillac, E., & Rivot, E. (2023). Modelling the distribution of rare and data-poor diadromous fish at sea for protected area management. *Progress in Oceanography.* 210: 102924. DOI: 10.1016/j.pocean.2022.102924.

Gregory, S.D., Gillson, J. P., Whitlock, K., Gough, P., Hillman, R. J., Mee, D., Peirson, G., Shields, B., Talks, L., Toms, S., Walker, A. M., & Davidson, I.C. (2023). Atlantic salmon rod exploitation rate estimation for principal salmon rivers in England & Wales. *ICES Journal of Marine Science.*

Dambrine, C., Lambert, P., **Elliott, S.A.M,** Boavida-Portugal, J., Mateus, C.S., Leary, C., Pauwels, I., Poole, R., Roche, W., Bergh, E., Vanoverbeke, J., Chust, G., & Lassalle, G. (2023). Connecting population functionality with distribution model predictions to support freshwater and marine management of diadromous species. *Biological Conservation.* 287: 110324. DOI: 10.1016/j.biocon.2023.110324.

Lilly, J…… **Elliott, S.A.M.,** et al. (2023). Migration patterns and navigation cues of Atlantic salmon post-smolts migrating from 14 rivers through the coastal zones around the Irish Sea. *Journal of Fish Biology*: DOI: 10.1111/jfb.15591.

Skora, M.E., Jones, J.I., Youngson, A.F., Robertson, S., Wells, A., **Lauridsen, R.B.,** & Copp, G.H. (2023). Evidence of potential establishment of pink salmon *Oncorhynchus gorbuscha* in Scotland. *Journal of Fish Biology,* 1–6. https://doi.org/10.1111/jfb.15304.

Tréhin, C., Rivot, E., Santanbien, V., Patin, R., **Gregory, S.D.,** Lamireau, L., Marchand, F., **Beaumont, W.R.C., Scott, L.J.,** Hillman, R., Besnard, A.-L., Boisson, P.-Y., Meslier, L., King, R.A., Stevens, J.R. & Nevoux, M. (2023). A multi-population approach supports common patterns in marine growth and maturation decision in Atlantic salmon *(Salmo salar L.)* from Southern Europe. *J Fish Biol.* https://doi.org/10.1111/jfb.15567.

ICES, 2023a. ICES. (2023). Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports.* 5:41. 478 pp. https://doi.org/10.17895/ices.pub.22743713.

ICES. (2023). The Second ICES/NASCO Workshop on Salmon Mortality at Sea (WKSalmon2; outputs from 2022 meeting). *ICES Scientific Reports.* 5:36. 69 pp. https://doi.org/10.17895/ices.pub.22560790.

2022

C.D Bull, **S.D Gregory**, E Rivot, T.F Sheehan, D Ensing, G Woodward, & W Crozier (2022). The likely suspects framework: the need for a life cycle approach for managing Atlantic salmon *(Salmo salar)* stocks across multiple scales, *ICES Journal of Marine Science.* https://doi.org/10.1093/icesjms/fsac099.

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

Marsh, J.E., Jones, I. J., **Lauridsen, R.B.,** Grace, J.B & Kratina, P. (online early). Direct and indirect influences of macrophyte cover on abundance and growth of juvenile Atlantic salmon. *Freshwater Biology*, doi:10.1111/fwb.13979.

Olivia Simmons, (2022). *Predicting how the juvenile life-stages of anadromous Atlantic salmon* Salmo salar *influence their migration phenology and marine survival.* PhD Thesis, University of Bournemouth. https://eprints.bournemouth.ac.uk/36846/.

2021

ICES (2021). Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports.* 3:29. 407 pp. DOI: 10.17895/ices.pub.7923.

ICES (2021). Workshop for Salmon Life Cycle Modelling (WKSalModel). *ICES Scientific Reports.* 3:24. 20 pp. DOI: 10.17895/ices.pub.7921.

Marsh, J.E., Cove, R.J., Britton, J.R., Wellard, R.G., House, A. & **Gregory, S.D.** (2021). Medium-term environmental changes influence age-specific survival estimates in a salmonid population. *Freshwater Biology*, 66, 1530-1545. DOI:10.1111/fwb.13736.

Marsh, J.E., Lauridsen, R.B., Gregory, S.D., Kratina, P., **Scott, L.J.,** Cooling, D. & Jones, J.I. (2021). High summer macrophyte cover increases abundance, growth, and feeding of juvenile Atlantic salmon. *Ecological Applications*, 32, e2492. DOI: 10.1002/eap.2492.

Marsh, J.E., Lauridsen, R.B., Riley, W.D., **Simmons, O.M., Artero, C., Scott, L.J., Beaumont, W.R.C., Beaumont, W.A.,** Davy-Bowker, J., **Lecointre, T., Roberts, D.E. & Gregory, S.D.**

(2021). Warm winters and cool springs negatively influence recruitment of Atlantic salmon *(Salmo salar L.)* in a southern England chalk stream. *Journal of Fish Biology*, 99,1125-1129. DOI: 10.1111/jfb.14760.

Simmons, O.M., **Gregory, S.D**, Gillingham, P.K., Riley, W.D., **Scott, L.J.**, & Britton, J.R. (2021). Biological and environmental influences on the migration phenology of Atlantic salmon *Salmo salar* smolts in a chalk stream in southern England, 66, 1581– 1594. DOI: 10.1111/fwb.13776.

Simmons, O.M., Britton, J.R, Gillingham, P.K., Nevoux, M., Riley, W.D., Rivot, E., & **Gregory, S.D.** (2021). Predicting how environmental conditions and smolt body length when entering the marine environment impact individual Atlantic salmon *Salmo salar* adult return rates. *Journal of Fish Biology*, 1– 11. DOI: 10.1002/JFB.14946.

Trehin, C., Rivot, E., Lamireau, L., Meslier, L., Besnard, A.-L., **Gregory, S.D.**, & Nevoux, M. (2021). Growth during the first summer at sea modulates sex-specific maturation schedule in Atlantic salmon. *Canadian Journal of Fisheries and Aquatic Sciences*, 78, 659-669. DOI: 10.1139/cjfas-2020-0236.

Picken, J. (2020). *The effects of low summer discharge on salmonid ecosystems*. PhD Thesis, Queen Mary University of London. https://qmro.qmul.ac.uk/xmlui/handle/123456789/72620.

Woodward, G., Morris, O., Barquín Ortiz, J., Belgrano, A., Bull, C., de Eyto, E., Friberg, N. Guðbergsson, G., Layer-Dobra, K., **Lauridsen, R.**, Lewis, H.M., McGinnity, P., Pawar, S., Rosindell, J. & O'Gorman, E.J. (2021). Using food webs and metabolic theory to monitor, model, and manage Atlantic salmon – a keystone species under threat. *Frontiers in Ecology and Evolution,* 9. DOI: 10.3389/fevo.2021.675261.

2020

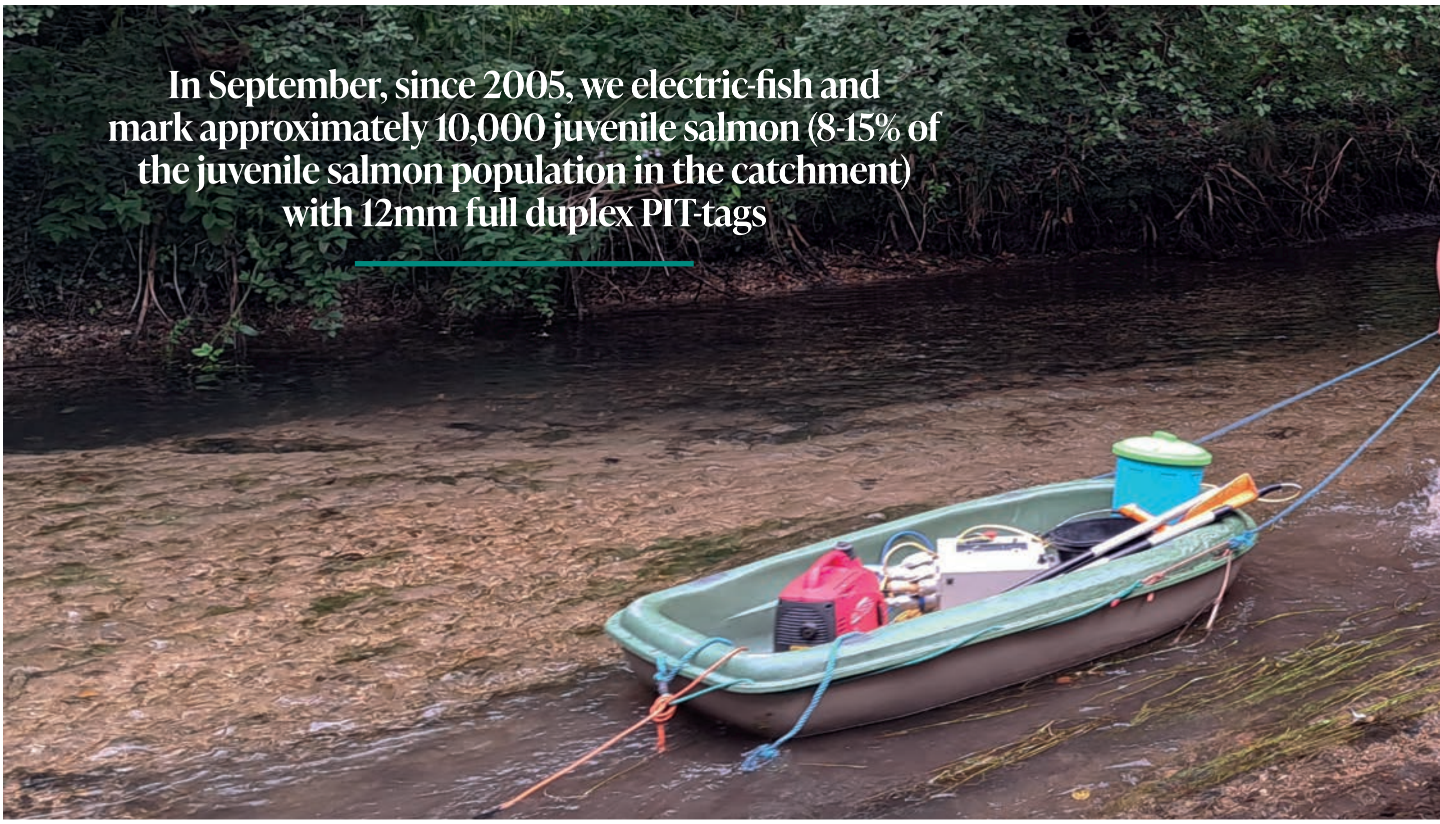
Gillson, J.P., Maxwell, D.L., **Gregory, S.D.**, et al. (2020). Can aspects of the discharge regime associated with juvenile Atlantic salmon *(Salmo salar L.)* and trout *(S. trutta L.)* densities be identified using historical monitoring data from five UK rivers? *Fisheries Management and Ecology*, 27, 567-579. DOI: 10.1111/fme.12456.

Gregory, S.D., Bewes, V., Davey, A. J. H., **Roberts, D.E.**, Gough, P. & Davidson, I. C. (2020). Environmental conditions modify density-dependent salmonid recruitment: insights into the 2016 recruitment crash in Wales. *Freshwater Biology*, 65, 2135-2153. DOI: 10.1111/fwb.13609.

Marsh, J.E. (2020). *The importance of* Ranunculus spp. *for juvenile salmonids in lowland rivers.* PhD Thesis, Queen Mary University of London. https://qmro.qmul.ac.uk/xmlui/handle/123456789/68323.

Marsh, J.E., **Lauridsen, R.B.**, **Gregory, S.D.**, **Beaumont, W.R.C.**, **Scott, L. J.**, Kratina, P. & Jones, J.I. (2020). Above parr: Lowland river habitat characteristics associated with higher juvenile Atlantic salmon *(Salmo salar)* and brown trout *(S. trutta)* densities. *Ecology of Freshwater Fish*, 29, 542-556. DOI: 10.1111/eff.12529.

Simmons, O.M., Britton, J.R., Gillingham, P.K., & **Gregory, S.D.** (2020). Influence of environmental and biological factors on the



over-winter growth rate of Atlantic salmon *Salmo salar* parr in a UK chalk stream. *Ecology of Freshwater Fish*, 29, 665-678. DOI: 10.1111/eff.12542.

ICES (2020). Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports*. 2:21. 358 pp. DOI: 10.17895/ices.pub.5973.

ICES (2020). NASCO Workshop for North Atlantic Salmon At-Sea Mortality (WKSalmon, outputs from 2019 meeting). *ICES Scientific Reports*. 2:69. 175 pp. DOI: 10.17895/ices.pub.5979.

2019

Gregory, S. D., Ibbotson, A. T., Riley, W. D., Nevoux, M., Lauridsen, R. B., Britton, J. R., Gillingham, P. K., Simmons, O. M., & Rivot, E. (2019). Atlantic salmon return rate increases with smolt length. *ICES Journal of Marine Science*, 76, 1702-1712. DOI: 10.1093/icesjms/fsz066.

Robertson, M. (ed), [13 authors], Gregory, S. D., [15 authors] (2019). Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports*, 1: 16. International Council for the Exploration of the Sea. DOI: 10.17895/ices.pub.4978.

ICES (2019). Working Group on North Atlantic Salmon (WGNAS). *ICES Scientific Reports.* 1:16. 368 pp. DOI: 10.17895/ices.pub.4978.

2018

Gregory, S.D., Armstrong, J.D. & Britton, J.R. (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, S.D. (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, J.R., King, R.W., Beaumont, W.R.C., Ibbotson. A.T. & Stevens, J.R. (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.

Moore, A., Privitera, L., Ives, M.J., Uzyczak, J. & Beaumont, W.R.C. (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 S.D., Lauridsen R.B. & 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.

Riley, W.D., Ibbotson, A.I., Gregory, S.D., Russell, I.C., Lauridsen, R.B., Beaumont, W.R.C., Cook, A.C. & Maxwell, D.L. (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.

For more details see **gwct.org.uk/fisheries.**

Contact us

SALMON & TROUT RESEARCH CENTRE
East Stoke, Wareham,
Dorset, BH20 6BB
Email: fisheries@gwct.org.uk
Tel: 01929 401893

gwct.org.uk

Design and Layout: Louise Shervington

Game & Wildlife
CONSERVATION TRUST