Salmon research report 2013

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MorFish
Monitoring for Migratory Fish

Game & Wildlife
CONSERVATION TRUST

www.gwct.org.uk/salmonreport

Contents

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Front cover: Salmon. © Laurie Campbell.
Below: Tagging parr; electro-fishing off a boom boat; monitoring salmon on the River Scorff in France.

1. Abstract

Welcome to the 2013 report from the Game & Wildlife Conservation Trust's Salmon & Trout Research Centre. This gives a brief summary of the research carried out on the salmon population of the River Frome, Dorset over the past year.

2013 was the 41st year of the salmon counter's operation at East Stoke. It was an extremely good year for the juvenile phases of salmon with high numbers of every life stage being recorded. For the adults it was very poor. Parr numbers in the river in September 2012 were very good: the third highest since 2002 and the number of autumn migrant parr that went past East Stoke was high: the second highest we have recorded. The spring monitoring of smolts was excellent and, at over 13,000, was over twice the number recorded in 2012.

On the adult count, equipment failure meant that some data that we normally collect on salmon movement was lost. For this reason we have added an efficiency estimate to the collected data to give an estimated nett upstream count of 343 fish. This is the lowest number ever recorded on the counter. Adult numbers calculated from PIT tag returns give an estimate very similar to this (383) so we are confident that the numbers were low. This low number of adults is also in agreement with our prediction last year about low numbers of grilse returning this year.

The collaboration with the Poole Harbour netsman continues with only one sea trout caught, tagged and released in 2013. Our research (with Cefas) on the effect of using rotary screw traps to assess salmon smolt numbers was completed and results will be analysed and written up as soon as possible. The research on the medium and long-term effect of Archimedes screw turbines on salmon smolts and eels also got underway using the facility at Bindon Abbey.

Our current Passive Integrated Transponder (PIT) tag detection equipment is getting very fragile and the manufacturer is no longer supplying new equipment. After reviewing available options we have found sponsorship and funding to replace the readers with new 'state of the art' equipment. The new detectors will be better able to withstand the high river flows we have recently experienced and installation should take place this summer.

Mean annual discharge (up to December) was above average, however, the mean monthly discharge in January 2014 was the highest ever recorded for that month.

Finally we are continuing to work with our French colleagues at INRA in Rennes, France, on the Monitoring for Migratory Fish (MorFish) project which will compare data to give us a better understanding of the changes in our populations of migratory fish.

Professor Nick Sotherton
Director of Research, Advisory & Education

Acknowledgements

The MorFish project has been selected in the context of the INTERREG IV A France (Channel) – England European cross-border co-operation programme, which is co-financed by the European Regional Development Fund.

We are grateful for the support of the following organisations and people: Freshwater Biological Association; Environment Agency; Centre for Environment, Fisheries & Aquaculture Science; the Frome, Piddle and West Dorset Fisheries Association; Mr Anthony Daniell; Aithrie Estates; Winton Charitable Trust; Zochonis Charitable Trust; Valentine Charitable Trust; Alice Ellen Cooper Dean Charitable Trust; Brendish Family Foundation; Iliffe Family Charitable Trust; Atlantic Salmon Trust; Salmon & Trout Association; Winton Capital and Mr Rupert Harris.

Bindon Abbey: The help and funding from the Lulworth Estate, the Salmon & Trout Association and the Environment Agency for these detectors is gratefully acknowledged. Clive Evans and Laurence Lloyd-Jones went above and beyond the call of duty in helping to build and install the tag detector frames.

We would like to thank Harry Warr and the Shaftesbury Estates for access and help in using the eel racks at East Burton for fish capture. Finally, but importantly, we are grateful to the many land and fishery owners on the River Frome. Without their co-operation in accessing the river much of this research would not be possible.

2. Introduction

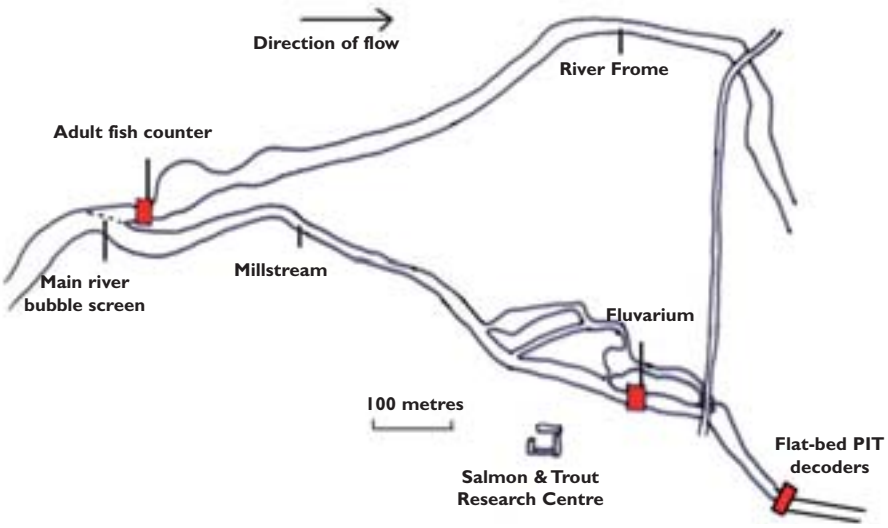
The estimation of upstream movements of adult salmon at East Stoke has been carried out since 1973. As such, it is one of the most comprehensive, long-term records of salmon movement in Europe.

Since 2009 the Game & Wildlife Conservation Trust (GWCT) has managed the counter ensuring the continuity of data collection. However, the help and support of the Freshwater Biological Association (who own the site) in enabling this continuation of monitoring is also gratefully acknowledged.

Over the 41 years of monitoring the salmon population we have also built up an unparalleled infrastructure both at East Stoke and elsewhere within the river catchment. This enables us to monitor both the migration of adult salmon upstream and the juveniles going downstream at a catchment scale. The site also allows the detection of small Passive Integrated Transponder (PIT) tags that we use to individually mark juvenile salmon. Figure 1 gives a schematic plan of the East Stoke site.

Figure 1

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



The combined counting and tag detection facilities for both adult and juvenile stages at East Stoke offers a unique opportunity to answer questions about salmon life history that would be difficult to repeat on other rivers. In particular, the use of PIT tag technology means that we are able to get a greater understanding of:

- The critical mortality phases of salmon.
- The site-dependant factors that affect mortality and emigration in the river.
- The interactions between the freshwater production of smolts and the marine production of adults.

Based on data collected on parr numbers in 2011 and smolt numbers in 2012, we predicted that grilse numbers were likely to be low in 2013: almost certainly due to the low flow conditions in 2011. This prediction proved to be correct and shows the importance of the freshwater phase survival as well as the marine problems the fish are experiencing.

3. Salmon research report

The principle aim of the GWCT salmon research on the River Frome is to estimate the population numbers of salmon at different stages in their life history (parr, smolt and adults). From this we can estimate the mortality between those stages and try to understand the causes of that mortality.

All of the population estimates for juvenile salmon rely on the detection of PIT tags in individual fish swimming past our array of PIT tag detectors on the main river. The high water levels early in 2013 meant that in the main river, PIT tag detection vanes had to be raised to prevent damage to them. By April the flow had subsided enough to lower the vanes and the system ran almost continuously for the rest of the year. In total 64 days were lost – with 61 of those being in the period February to April when few fish would have been moving.

Parr populations

Trying to estimate the total number of parr in the whole river is very difficult. If carried out by electro-fishing alone you would have to fish every metre of the river: an impossible undertaking. However, it is possible to estimate population numbers by marking some of the population and then sampling the population later-on and seeing what proportion are marked. We use a variation of this method to determine the number of parr in the river. We mark the fish in September using PIT tags as our method of marking, and recapture them (either physically or just by detecting the tags) in the autumn and spring migration periods as they swim past East Stoke.

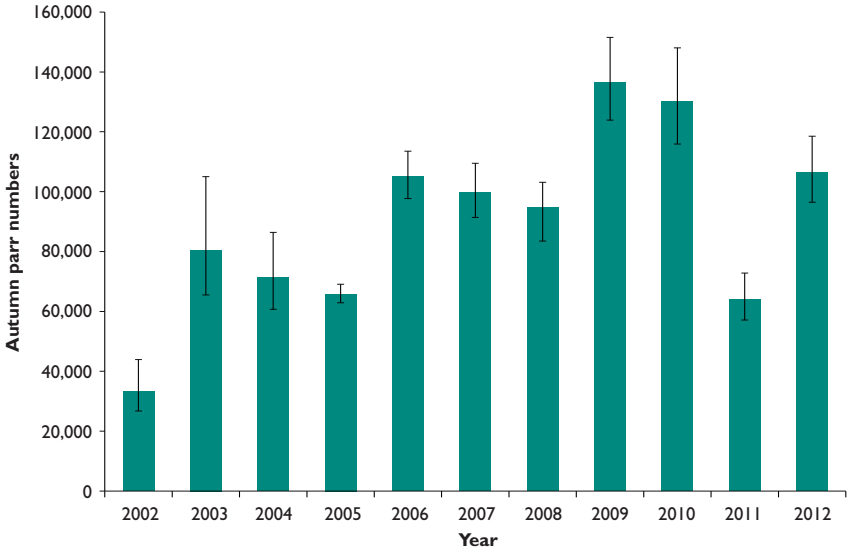
In September, for each of the past nine years, we have electro-fished and tagged approximately 10,000 juvenile salmon (about 10-15% of the juvenile salmon population of the whole river) with PIT tags. These small tags (just 12mm long x 2mm wide – see picture) are inserted into parr and enable us to individually identify the fish when they swim past any of our readers. We also remove the adipose fin (the small one behind the dorsal fin) so that we and other fishery surveys can identify tagged fish when they are recaptured. In 2013 we tagged over 10,500 parr.

Salmon parr and PIT tag (circled). Individual ID of the tag is shown on the label.

The passage of the PIT tagged fish out to sea is recorded by equipment mounted on the East Stoke smolt counter and the main river weir. The main river reader also allows the detection of the returning PIT tagged adult fish. There are also detectors mounted on the Louds Mill fish pass at Dorchester, at Tadnoll Mill on the Tadnoll Brook and the weir, hydro-turbine system and fish-pass at Bindon Abbey.

This combination of autumn tagging and spring smolt counting with tag detection allows us to get an estimate of the total number of salmon parr in the river in the autumn. We need to know the number of tagged fish in the following year's smolt run to calculate this so only data to 2012 can be shown (see Figure 2). These records, together with the records from the other PIT tag readers, are giving us uniquely valuable information about freshwater survival rates. The information will enable us to determine survival from individual reaches of the river and link the growth rates of the juvenile fish with the time of migration. Data on freshwater survival, marine survival and life history strategy from different tributaries will also be obtained.

Figure 2
Estimated autumn parr numbers with confidence limits



Our autumn tagging and spring smolt counting help us to estimate the total number of salmon parr in the autumn.

Autumn migrants

The PIT tag detector vanes on the main weir also allow us to monitor the 'autumn' downstream run of parr in the river (see Figure 3).

Some parr move downstream in the autumn and reside in the lower river over winter.

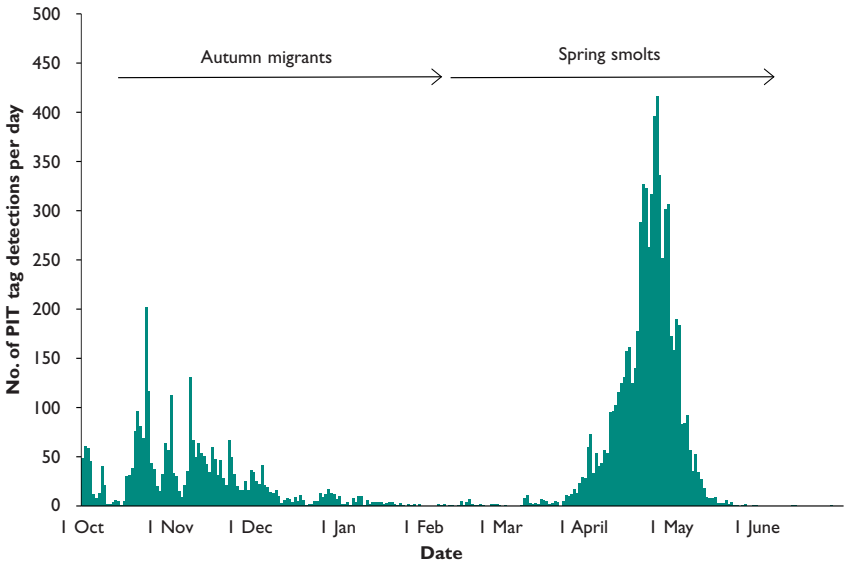


Figure 3
Records of 9,927 parr/smolt detected moving down past East Stoke (2005-2010)

Although this phenomenon has been reported before, it has not been fully studied, quantified or explained. Our studies to date show that this movement is an active downstream migration ie. the fish are not just passively drifting downstream. However, on the other hand, the fish are not able to tolerate salt water. We have found that many of these fish reside over winter in the lower river as far downstream as Wareham and we are currently undertaking experiments to better understand this behaviour. We have recorded the first return of an adult fish that was an autumn migrant (Riley *et al.* 2009) and we will continue to examine returns from the adult fish to see if the survival of these early moving fish is better than the fish that migrate in the spring, the 'usual' migration time for the smolts. We are also looking at the additional dangers these 'autumn migrants' face in the lower river.

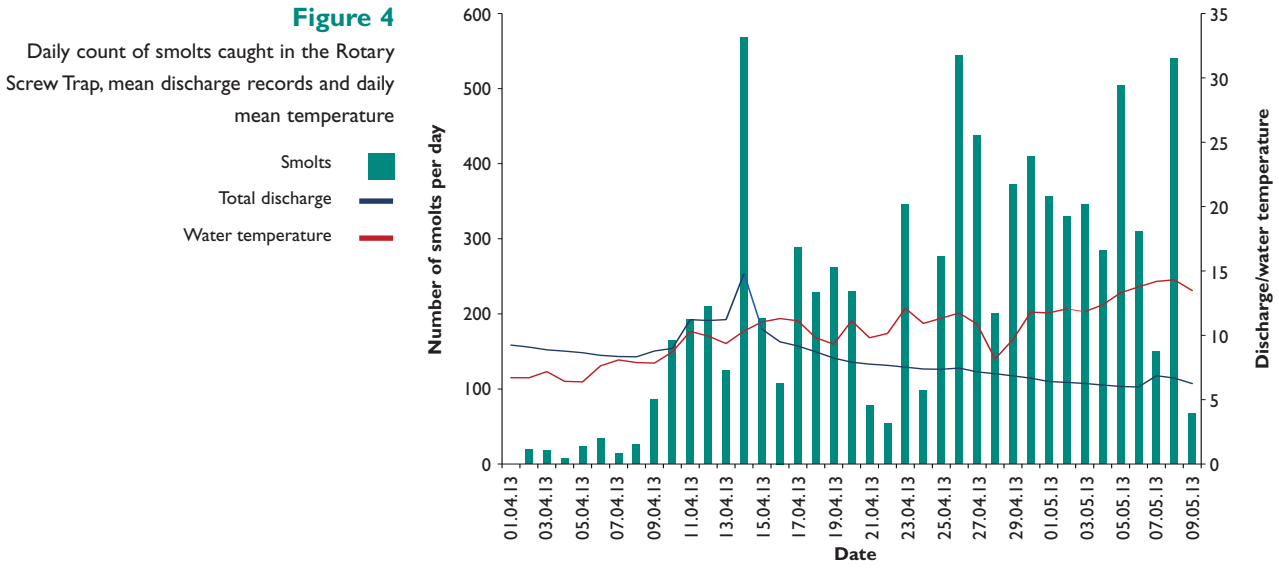
Salmon smolts swim down the river and are diverted down the millstream by the acoustic bubble screen.

Smolt counting

Since 1995 we have been counting the number of smolts emigrating from the river. To do this we use a device called a Bio-Acoustic Fish Fence (BAFF) to divert the fish into the millstream at East Stoke. The BAFF is simply a curtain of bubbles that also has sound entrained within the bubbles, thereby using both the visual impression of a barrier (the bubbles) with the sound to divert the fish. As any tagged fish that do pass through the deflector have to pass out through the detectors on the main river weir, we get an estimate of the efficiency of the BAFF system. This has been shown to be very good, with deflection rates of above 80%. We use this deflection efficiency to calculate total numbers of smolts migrating down the river. Provision is made for adult fish to be able to negotiate the apparatus and additional studies have

Figure 4

Daily count of smolts caught in the Rotary Screw Trap, mean discharge records and daily mean temperature



shown that the system does not affect upstream adult movement. In the millstream the fish pass through the fluvarium tanks where (being a smaller volume of water) we can more easily count them electronically.

The daily smolt migration pattern for 2013 is shown in Figure 4. Data are from the Rotary Screw Trap. This trap ran continuously for the six weeks of the smolt run this year and gives a good indication of the run pattern.

The data from the early years of the smolt counting are not good quality and in some years no estimate at all was possible. However, as equipment and methods have been improved, better estimates have been possible. Figure 5 shows the annual smolt count, with numbers in 2013 the third highest that we have recorded in 12 years. We believe that there is a serious gap in our knowledge of juvenile salmon over the winter period. Our spring smolt output appears to be low in comparison with the number of parr the river holds in the previous September, even after accounting for the autumn migration. We have therefore started a new study of the over-wintering ecology of salmon parr, concentrating on migration, habitat requirements and habitat shifts. We will report on this work in future years.

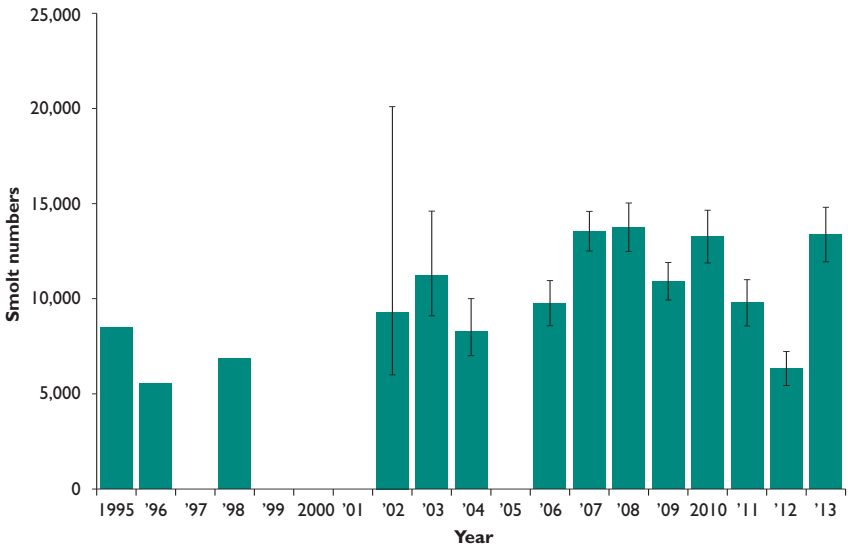


Figure 5
Annual smolt estimate and confidence limits (where available)

Adult numbers

Data are collected by a Scottish Hydro-Electric Mk Xb resistivity counter connected to three stainless steel electrodes mounted 450mm apart on the Environment Agency 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) passes over the electrodes the resistance changes and is registered on the counter. A full description of the history of the counter and preliminary long-term results are given in Beaumont *et al.* (2007).

In conjunction with data on salmon movement, information on water temperature, air temperature and light levels are also collected at 15 minute intervals from a purpose-built instrumentation and an on-site weather station. Hydrological (discharge) summaries are derived from Environment Agency data (Copyright © Environment Agency). All data are collated as hourly records.

Salmon run data are presented for the period February to January inclusive. Past data and personal observations indicate that the majority 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.

Data are presented either as total numbers ascending or descending or nett numbers ascending (ie. upstream minus downstream). Unless noted, all data are for verified counts.

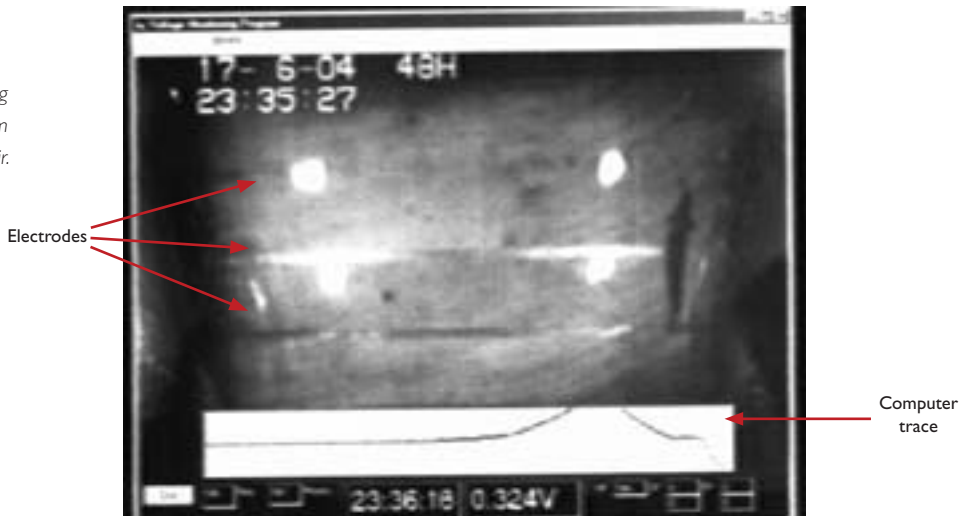
During January, February and March the downstream counts are not subtracted from the upstream counts as a high percentage are caused by downstream moving

The weir at East Stoke with the PIT tag detecting vanes raised for their annual service.

kelts (post-spawning salmon). Some kelts, however, carry out repeated up and down movement over the weir and if down-counts are not subtracted this can lead to over counting these fish. Therefore, where it is clear that up-counts have been caused by kelts, these are subtracted from the totals.

Data verification

A large part of the effort in running the East Stoke counter is focused on verifying and matching the various 'counts' from the monitoring equipment. Data are verified by a combination of trace waveform analysis (see Beaumont *et al.* 1986), video frame-grab and videotape analysis. In addition, frame grabs can be taken from the computer screen and stored. Only rarely are raw, unverified data used. An example of the computer verification system's display is shown below. A salmon can be seen on the video picture and the electrical trace is shown on the bottom section of the screen. Text boxes along the bottom of the display record, number of records; number of frame grabs; input signal value; time of day; number of records registered by computer and counter.



Screen display from the computerised counting and evaluation system. The image shows a 75cm salmon ascending the weir.

When the computer and video system was operational, accuracy of waveform assessment was carried out by comparing identity assessed from computer waveform traces with identity observed from video records. For periods when the computer system was not operational, counts were assessed by direct examination of the video data. Raw data from the counter are rarely used in an unverified form and the data for the run are compiled from a combination of counter, computer and video records ie. all computer trace records and counter records are checked on the video to identify the cause of the record. Raw fish counter data are only used when computer or video data are not available. Provided adequate water clarity, video records are 100% accurate and assessment of accuracy of interpretation of the computer records is made from comparing trace identity with the video records. Where water clarity is poor, just computer trace records are used to verify data.

Despite the electronic counter working 364 days last year, the logger we use to collect the data from the electronic counter failed. This meant that dates and times of potential fish that would normally be checked on the video system were not available. To compensate for this (potential) reduction in numbers, the waveform counts have this year been adjusted for accuracy. This accuracy figure is obtained from the video data that is viewed independently of the waveform data. A total of 23 days of video records were watched to check the detection accuracy. Adult numbers given are therefore estimated rather than absolute counts.

Only seven days of waveform verification were lost (due to the computer crashing and power cuts). Video data were collected for 224 days and these did not include times when the video was running but the water was too turbid to identify or see fish. There were no days without verification of count data from any source (waveform or video).

(Far left) A large sea lamprey;
(Left) A shoal of mullet going over the weir.

Adult data 2013

Figure 6 shows daily upstream and downstream counts together with mean daily discharge data. The table shows monthly data from the counter and gives gross upstream and gross downstream counts as well as the nett upstream count and the number of ascending kelts not included in the upstream records.

The estimated number of adult salmon ascending the river is 343

Data from the PIT tagged returning adults can also be used to calculate the population size. Using this method gives a total run of 383, confirming the low estimate above.

Figure 7 shows the historic annual nett run data (with pre-1985 data being corrected for down-counts). The run of fish in 2013 is the lowest ever recorded for the Frome.

Figure 8 shows time of day of fish movement over the weir. The avoidance of daylight hours during the summer months and the preference for daylight in the October to December period can be clearly seen. As yet we are not sure of the reason for this variation in run pattern.

PIT tagged adult returns

Repairs after the 2012 floods kept the main river PIT tag reader out of action until April. However, the low and steady flows in 2013 resulted in good conditions until the floods in December when we had to lift the vanes to avoid damage. Over the year the system was fully operational for 73% of the time; detecting 18 PIT tagged adult salmon. The PIT tag readers installed at Bindon Mill detected 17 adults with 10 individuals recorded on both readers giving a total of 25 tagged adult salmon detected.

Fish size and sea age

This salmon was a huge 135cm long and probably weighed more than 50lbs.

We measured lengths of 189 upstream migrating fish in 2013 (Figure 9) with the largest being a fish of 135cm (see photo). This huge fish was a male and had also been hooked by an angler in the lower river; much to his consternation when it threw the hook before being landed. Given the length of this fish, when it first returned to freshwater it probably weighed around 25kg (50+ lbs). Length estimates include data where only approximate length data are available. These are from periods where there was some turbidity in the water and only approximate (± 5cm) length data can be obtained. In past years these data were not used leading to a loss of data that still has some value in assigning sea-age to migrating fish. Data from fish below 50cm and fish that are obviously the same fish vacillating over the weir have been excluded from the data set.

The length data obtained from the video records are used to calculate the proportion of one sea-winter (grilse) and multi-sea-winter (MSW) fish migrating each month. This proportion is then used to calculate the numbers each month and for the whole year. Size limits for grilse have been calculated from the historic scale data from the Frome that we have. These data, however, may have inaccuracies due to changing sizes of the grilse (getting smaller) that have been reported since the size thresholds were calculated. As yet we do not have sufficient new data to recalculate these thresholds. There are also some inaccuracies caused by low numbers of measured fish unduly influencing the proportions. However, the data provide a starting point for examining the partition between grilse and MSW fish and its variation over the years.

Sea survival of adults

As outlined above, we have been concerned about the accuracy of our estimates of grilse and multi-sea-winter fish that we get from our length data. However, we now have sufficient data from our returning PIT tagged salmon that we can get data on sea survival (a slightly different way of expressing return rates for the different sea ages) from tag returns. This also gives us absolute separation of one, two and three sea winter fish: something few other river monitoring sites are capable of. We will be working on this historic data in the coming year.

Hourly database

Appendix I shows data from the hourly database for each month. As well as total upstream salmon numbers in an hour, hourly averages (4 x 15 minute readings) of water discharge ((East Stoke Millstream (ESMS) discharge is shown separately as dark blue on top of light blue main river (East Stoke flume) discharge – upper boundary of data therefore is total discharge) from Environment Agency data). The temperature logger started giving false data last year and this data will (for 2013) be sourced from the Freshwater Biological Association temperature logging systems being operated at East Stoke.

4. Other studies

Bindon Abbey

This year we installed a different design of PIT tag reader into the various hatches and hydro-turbine tail race at Bindon Abbey. The new detectors are designed to detect parr and smolts swimming in the mid- and upper-water column as well as the adults on the bottom.

Although modern Archimedes turbine designs are meant to be 'fish friendly' no medium or long-term data are available to verify this. By detecting parr and smolts migrating downstream through the turbine, we can then see if there is a difference in survival to East Stoke (2.8km downstream) than those that use different migration routes. By detecting the subsequent return of adults we should be able, in time, to assess long-term effects of passing through the turbine.

With the current PIT tag readers it is also possible to study if the adults are held up around the turbine outflow or whether they migrate up the pass or hatches without undue delay.

The new detectors are at the limit of the technology and considerable teething problems were experienced with commissioning them. This resulted in the units having to be returned to the manufacturer over the period of the smolt run. The detectors have subsequently been reinstalled (including repositioning the turbine tag detectors) and we are now collecting data from them.

(Inset) The Archimedes turbine being installed at Bindon Abbey. (Below) The multiple PIT tag detection antenna system installed at the bottom of the hydro-turbine will help us to determine how 'fish friendly' these turbines are.

We are investigating whether fish that have been caught in the Rotary Screw Trap have higher marine mortalities.

Rotary Screw Trap experiment

We have completed our joint study with Cefas on the effect of Rotary Screw Traps (RSTs) on subsequent smolt survival (see Figure 4). RSTs are widely used to trap and count migrating salmon smolts on other rivers. However, there have been concerns that the process may be detrimental to the fish. This project involves us using the information that we get from monitoring the PIT tagged fish to assess whether fish that have been trapped in the RST have higher marine mortalities. Results will be written up this year.

Poole Harbour netting

Under an agreement with the River Frome salmon net licence holder, the Environment Agency and the Frome, Piddle & West Dorset Fisheries Association we are monitoring the salmon and sea-trout net catch from Poole Harbour. All salmon and sea-trout caught are tagged using a visible Floy tag and/or a PIT tag implanted into the body cavity of the fish. The fish are then released and we see if they are caught by the rods or pass the East Stoke detecting equipment.

GWCT staff accompanied the netsman on four netting occasions. Only one sea trout was caught, PIT tagged. floy tagged and released. We have not detected it on the PIT tag detectors in the river.

Sea trout caught and released from the Poole Harbour net. Note the Floy tag by the dorsal fin.

MorFish (Monitoring For Migratory Fish)

In June 2012 the Fisheries department was successful in getting EU Interreg funding. The project is called MorFish (Monitoring For Migratory Fish) and involves working in partnership with the Institut National de la Recherche Agronomique (INRA) based in Rennes, Brittany.

The project will run until June 2015 and we will be collaborating to deliver three key objectives:

- Aligning the data collection on salmon populations on the Rivers Frome in Dorset and the Oir and Scorff in Brittany.
- Aligning and interrogating long-term environmental and salmon population data sets from both organisations.
- Generating management advice for mullet and sea lamprey using the facilities on the Frome, Oir and Scorff.

These objectives will enable the three rivers to collect data in a similar way so that the data collected is compatible and can be analysed together, thus providing a better understanding of the drivers behind changes in our populations of migratory fish.

We are working with French scientists on the MorFish project.

River flow

Figure 10 shows mean monthly discharge data (in cubic metres per second (cumecs)) for 2013 together with average (1966-2012) 5 percentile (%ile), 25%ile (Q1), 75%ile (Q3) and 95%ile discharge data. Values represent the percent time that discharge has historically been below the stated value (ie. for the 5%ile, values have only dropped below this level for 5% of the time and 95%ile, flow have been below this value for 95% of the time (since 1966)). These data are collated and calculated from Environment Agency records.

Following on from the extremely wet 2012, the river discharge started the year at very high levels (at or below the 95%ile). It then steadily dropped over the rest of the year reaching a yearly minimum in September when it was below the 5%ile. October and November flows were lower than average, but in December levels rose rapidly to just above the 75%ile (Q3).

Figure 11 shows that overall the mean annual discharge data for the Frome was above average.

5. References

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Riley W D, Ibbotson A T & Beaumont W R C (2009). Adult returns from Atlantic salmon, *Salmo salar L.*, parr autumn migrants. *Fisheries Management & Ecology* 16: 75-76.

	MONTH													
Month	*Feb-13*	*Mar-13*	*Apr-13*	*May-13*	*Jun-13*	*Jul-13*	*Aug-13*	*Sep-13*	*Oct-13*	*Nov-13*	*Dec-13*	*Jan-14*	Total	Corrected
Gross U/S	0	3	4	22	45	103	9	2	58	20	48	0	314	419
Gross D/S	1	2	3	1	5	27	3	2	8	1	20	3	76	76
Nett U/S	0	3	1	21	40	76	6	0	50	19	28	0	244	343

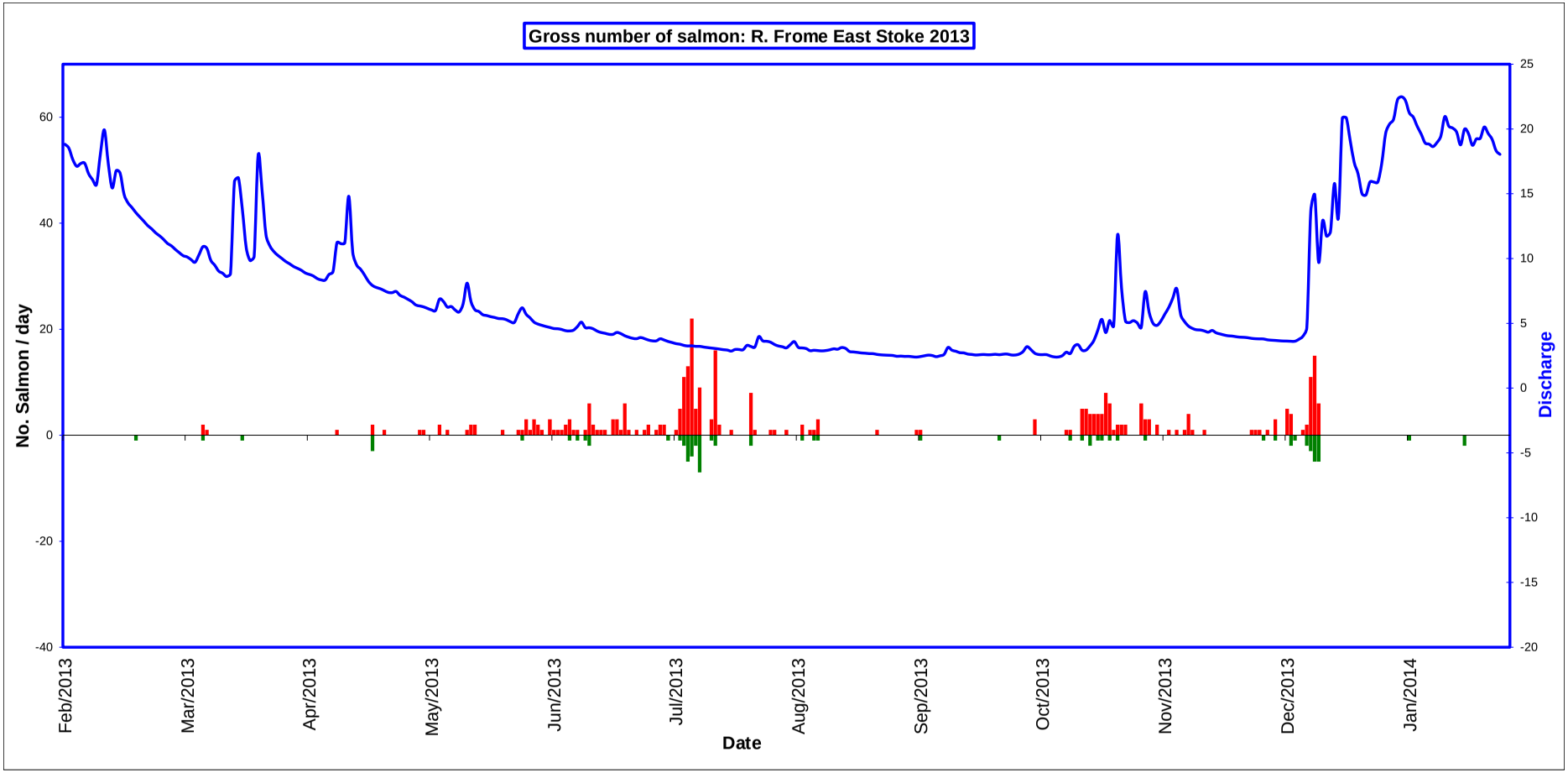


Figure 6 East Stoke Salmon Counter Data 2013

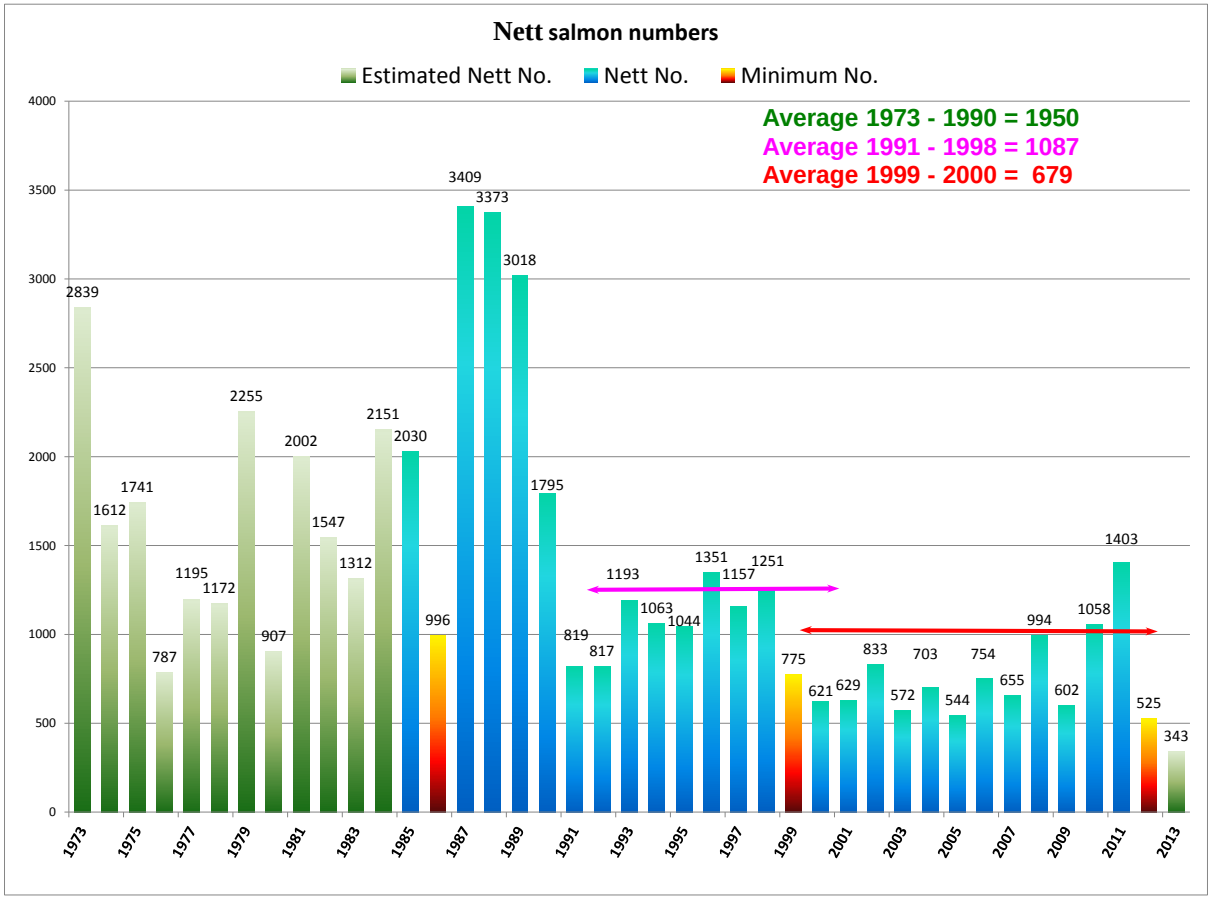


Figure 7 Annual numbers of salmon ascending the East Stoke weir

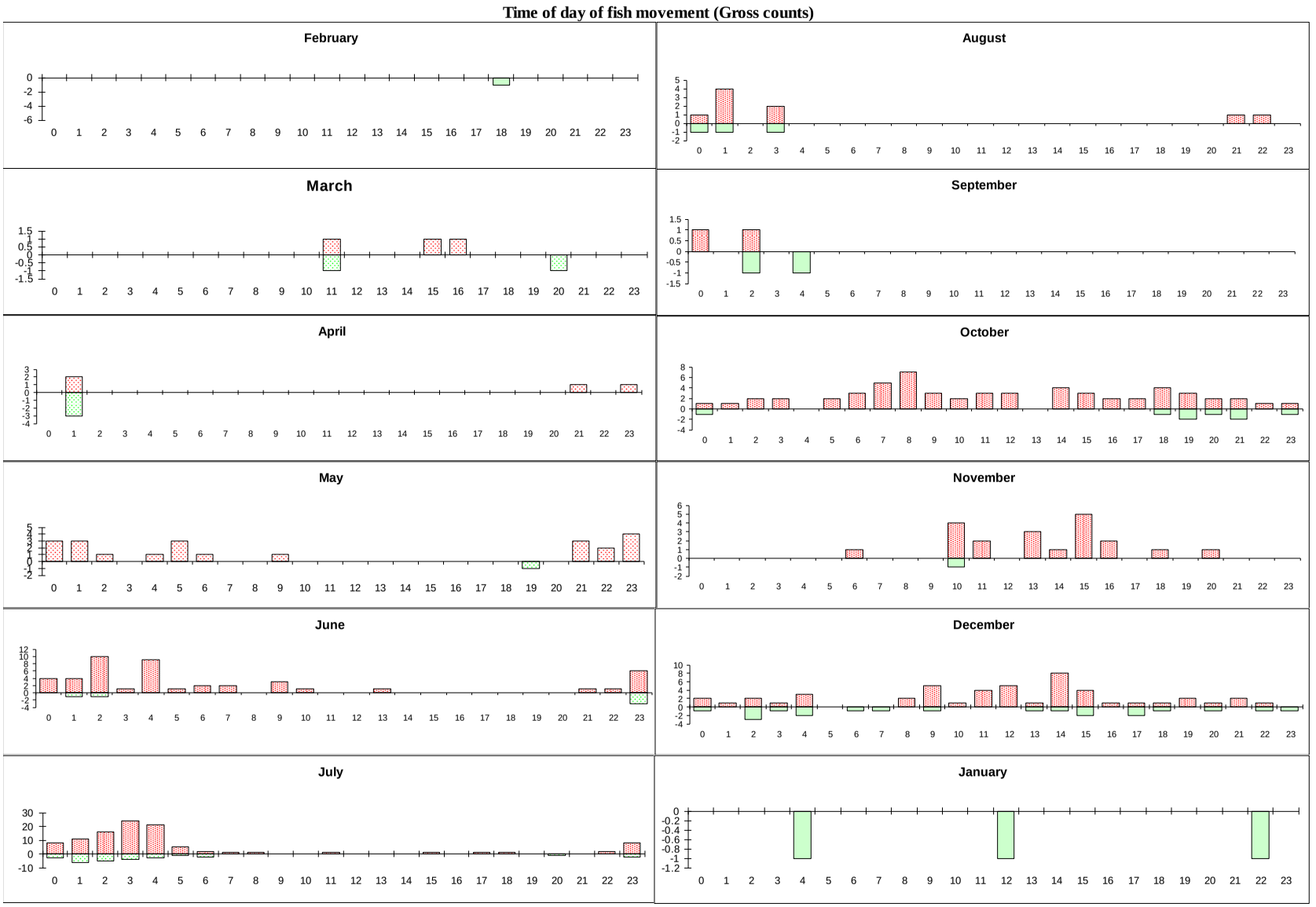


Figure 8 Time of day of movement (Gross upstream and downstream count data)

Observed Salmon Lengths 2013:

Upstream migrating fish >50 cm only

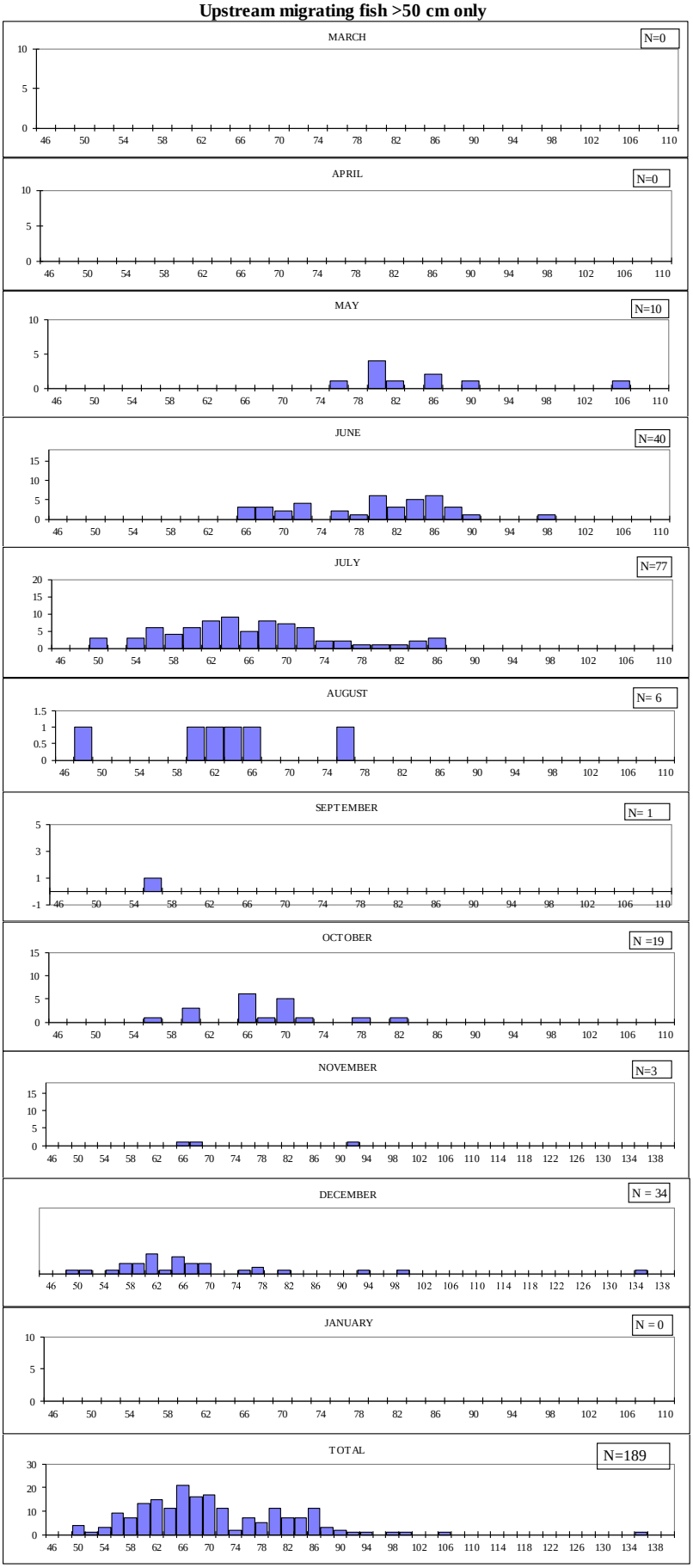


Figure 9 Length (cm) of upstream migrating fish each month

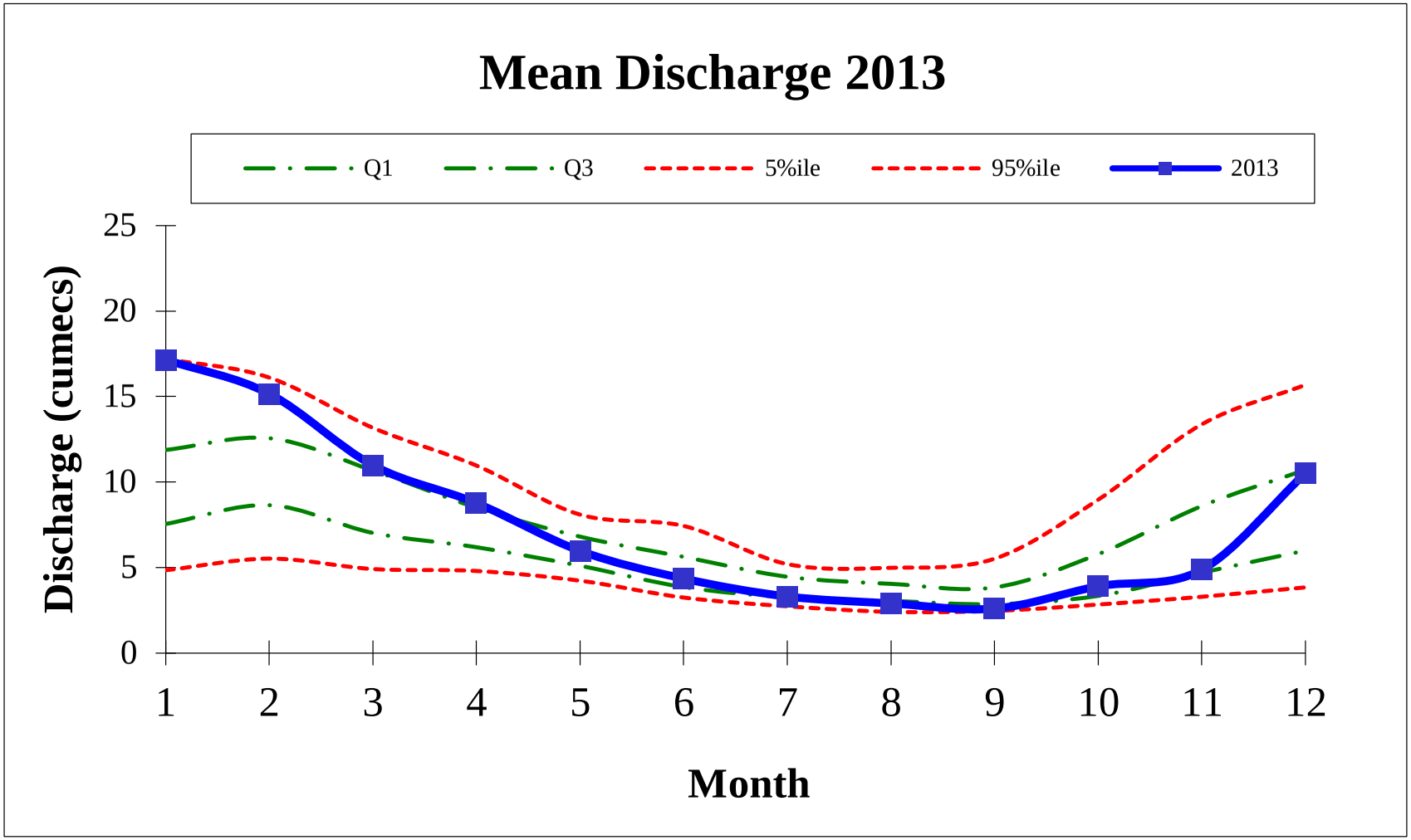


Figure 10 Monthly mean discharge and long-term percentile data (Jan-Dec data)

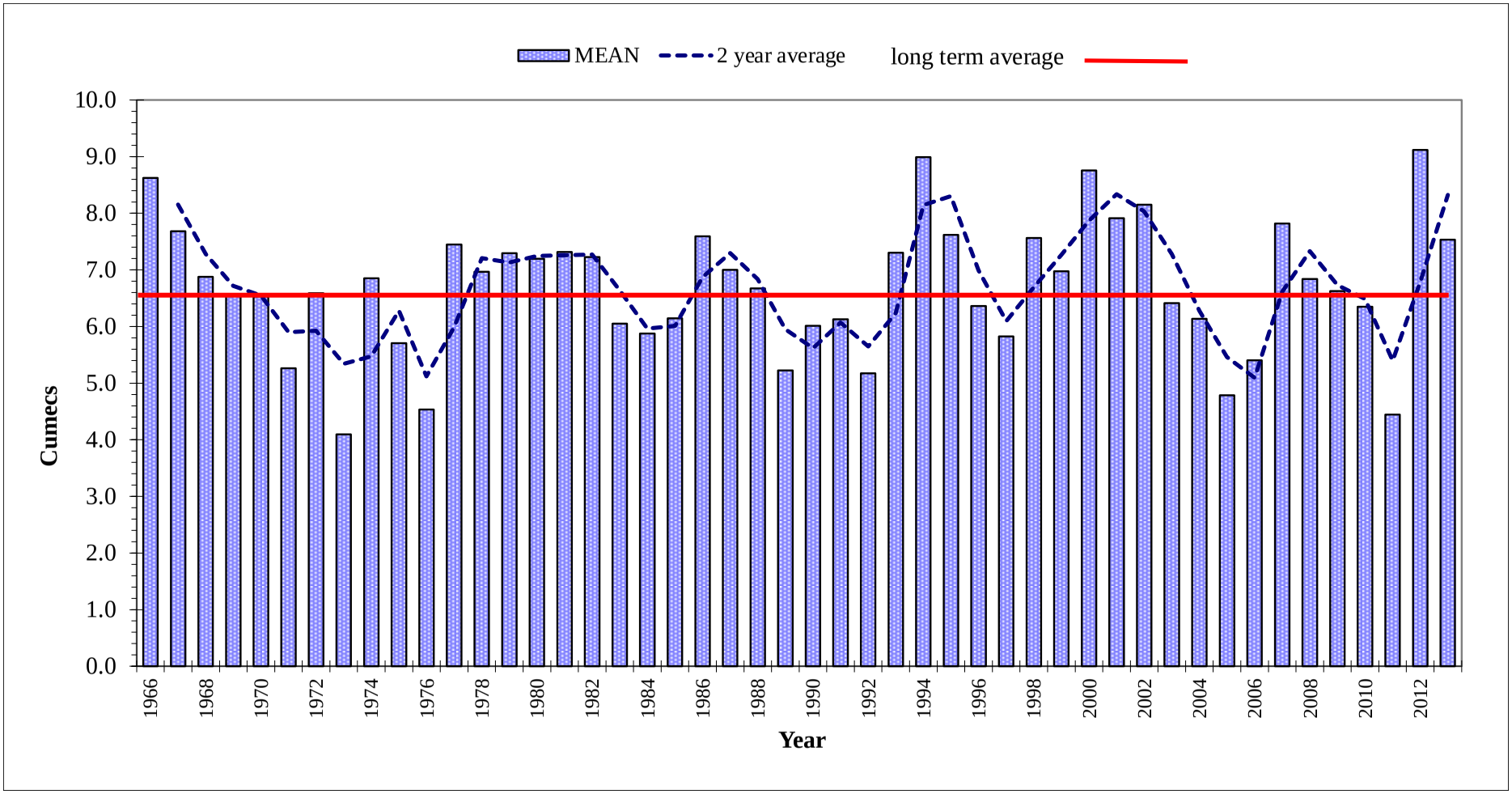
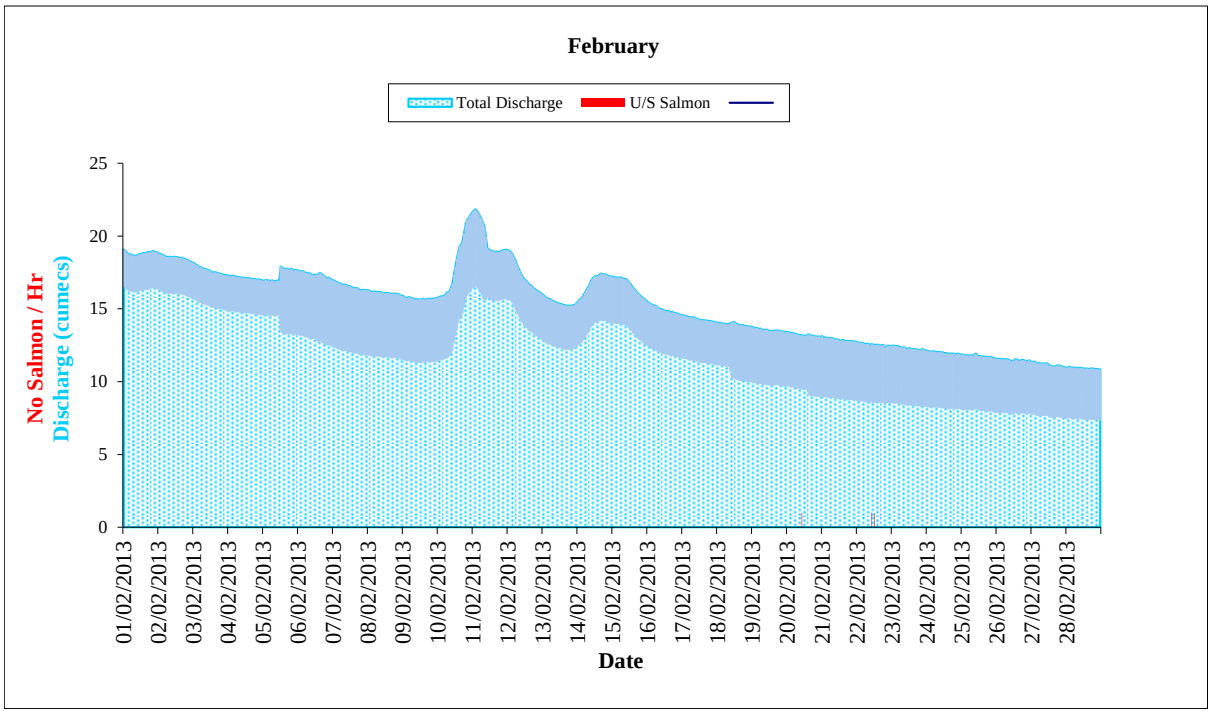
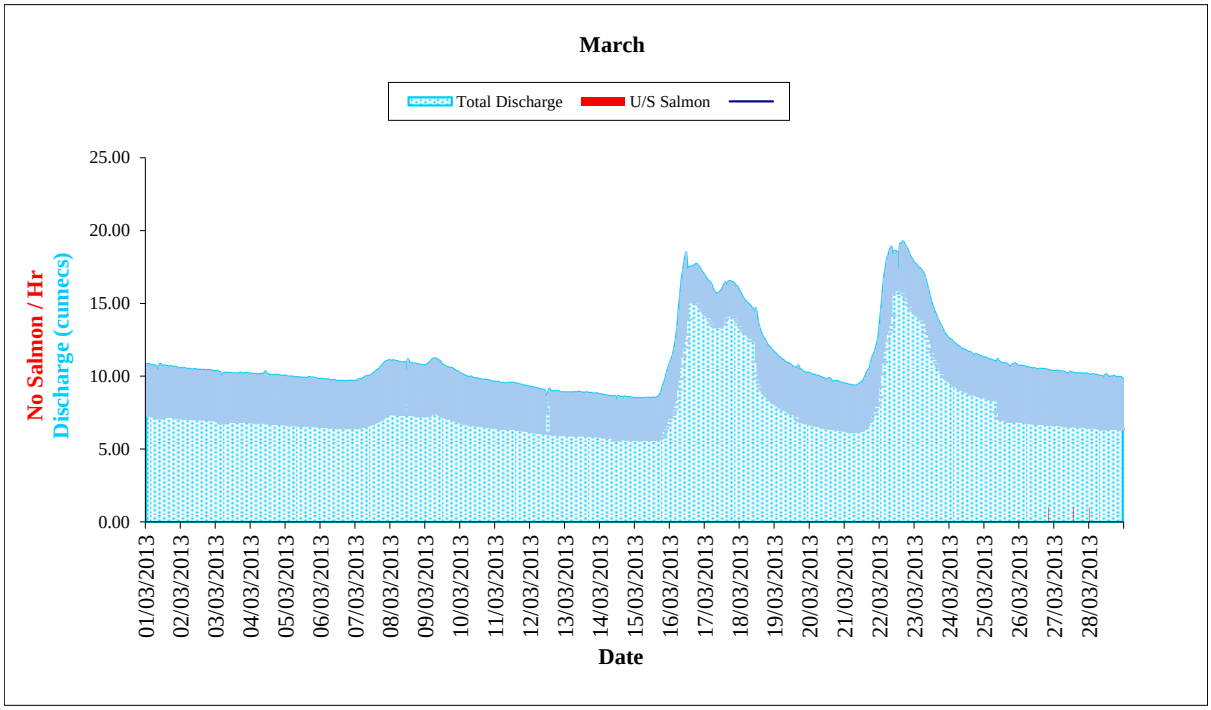
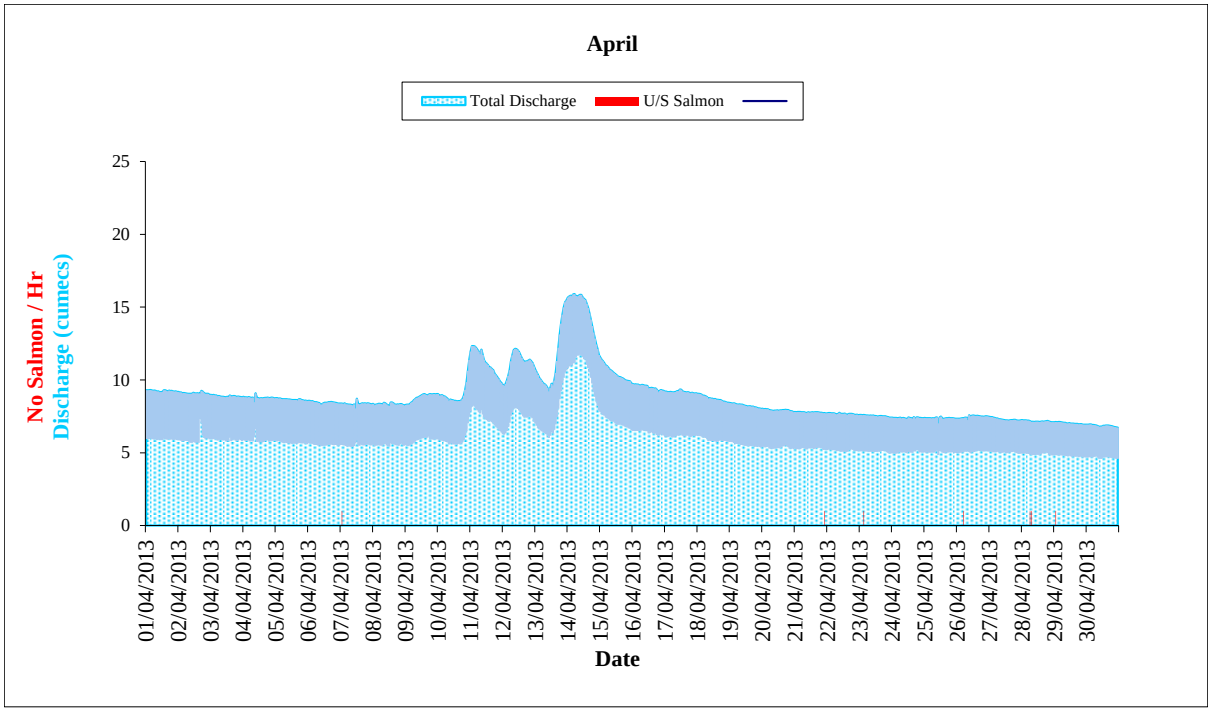


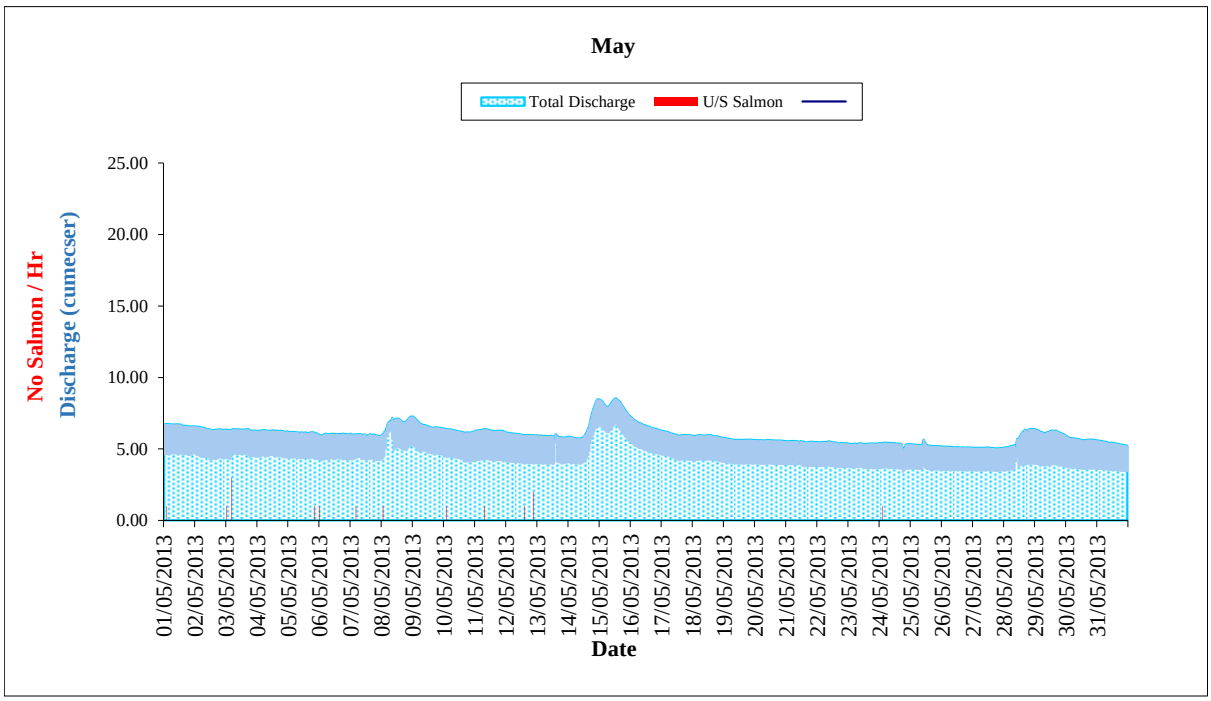
Figure 11 River Frome long-term annual discharge



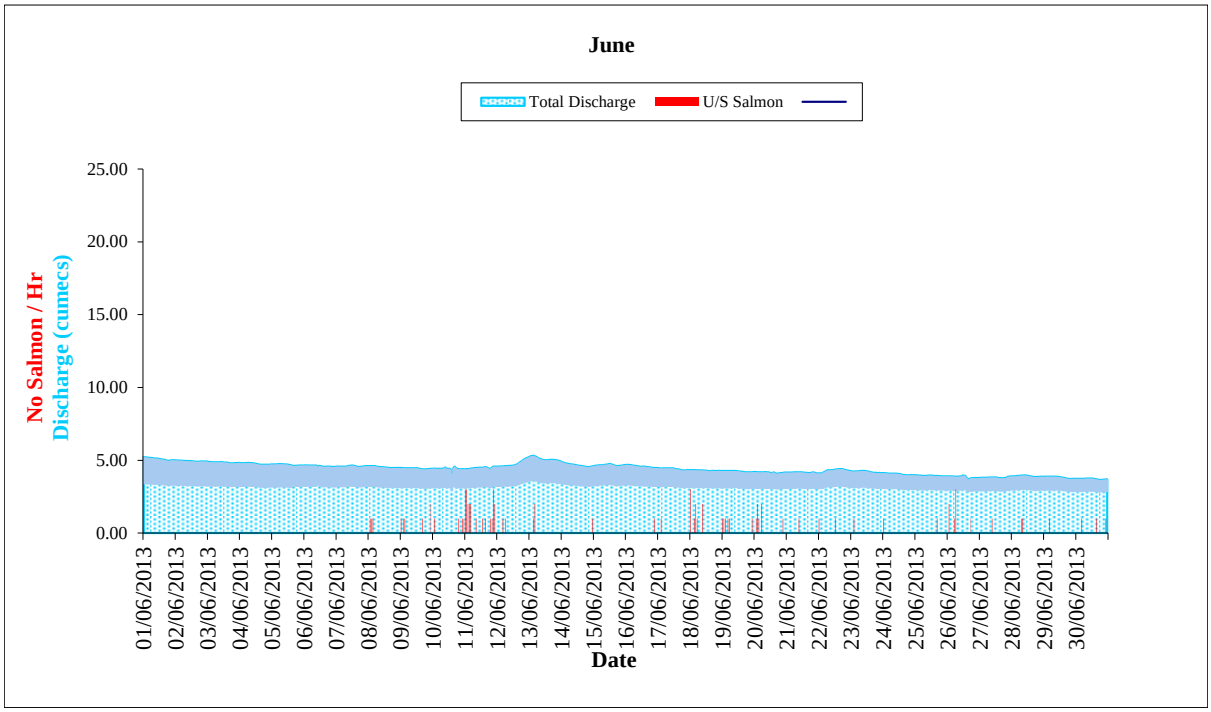


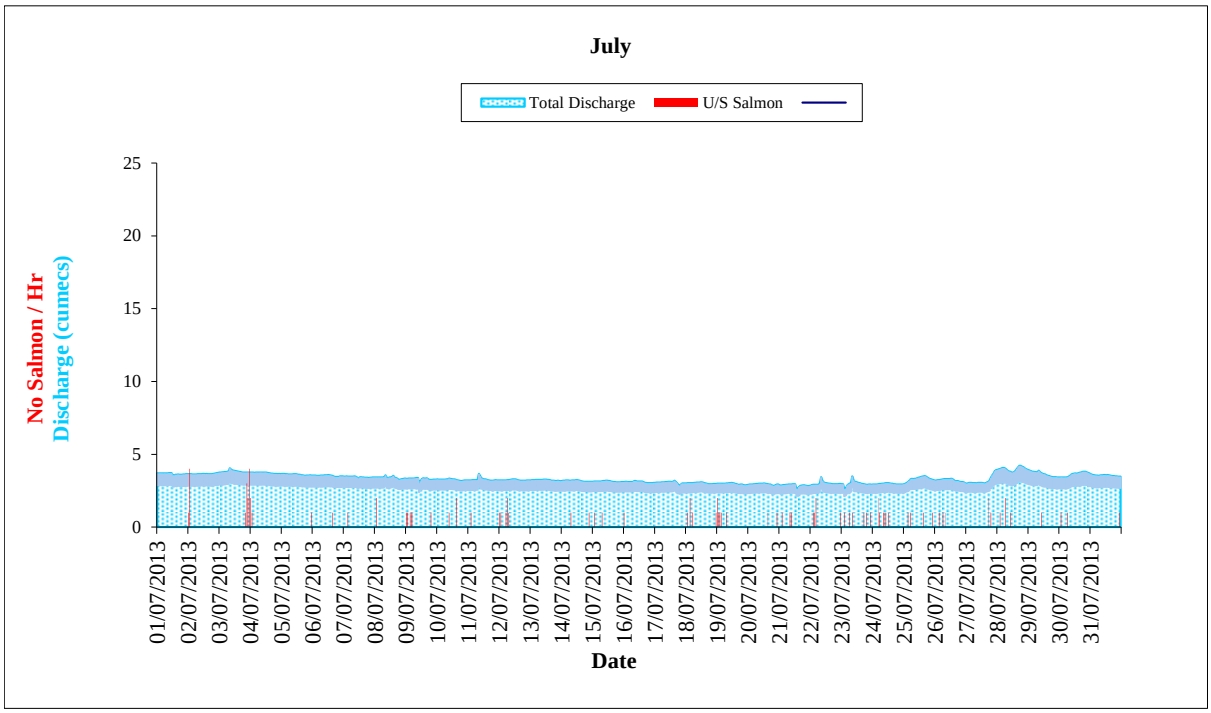
Appendix I Hourly data



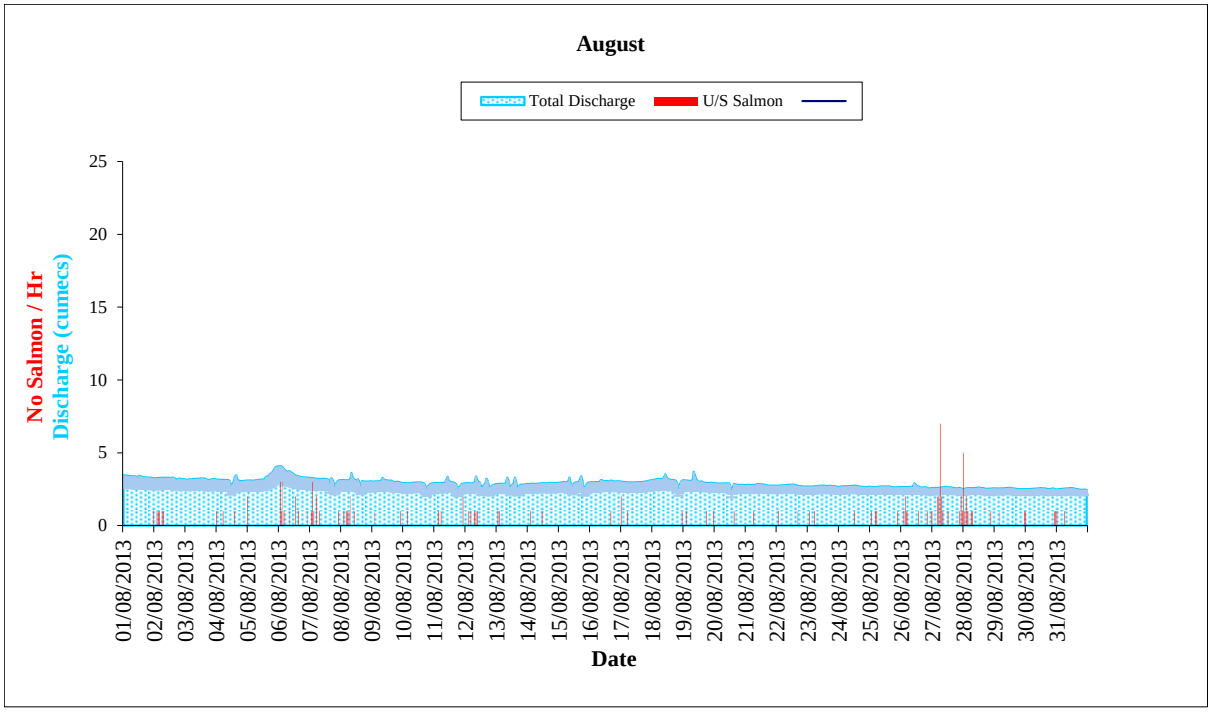


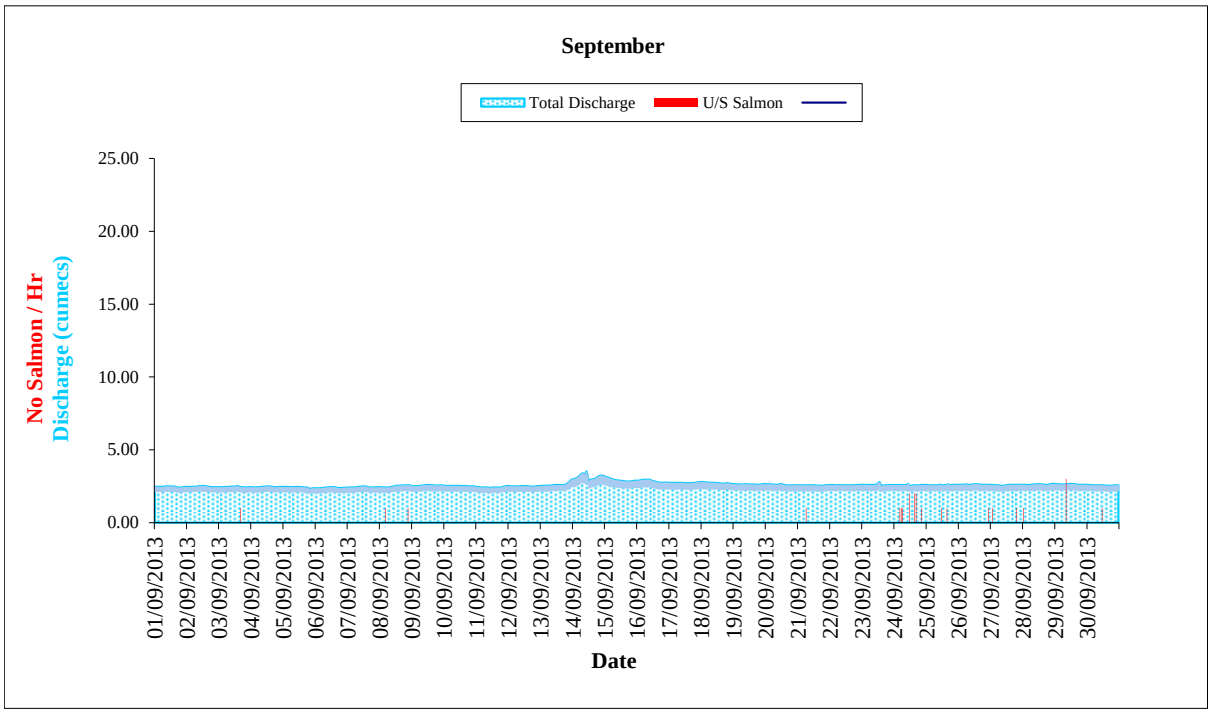
Appendix I Hourly data



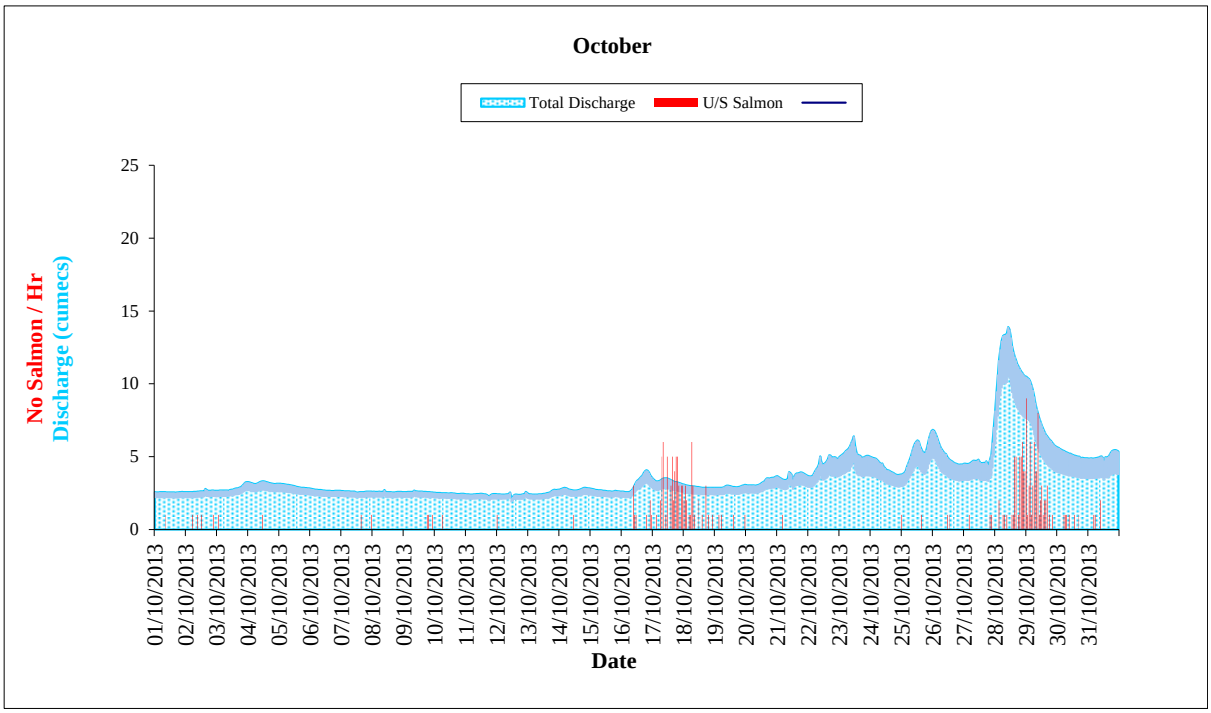


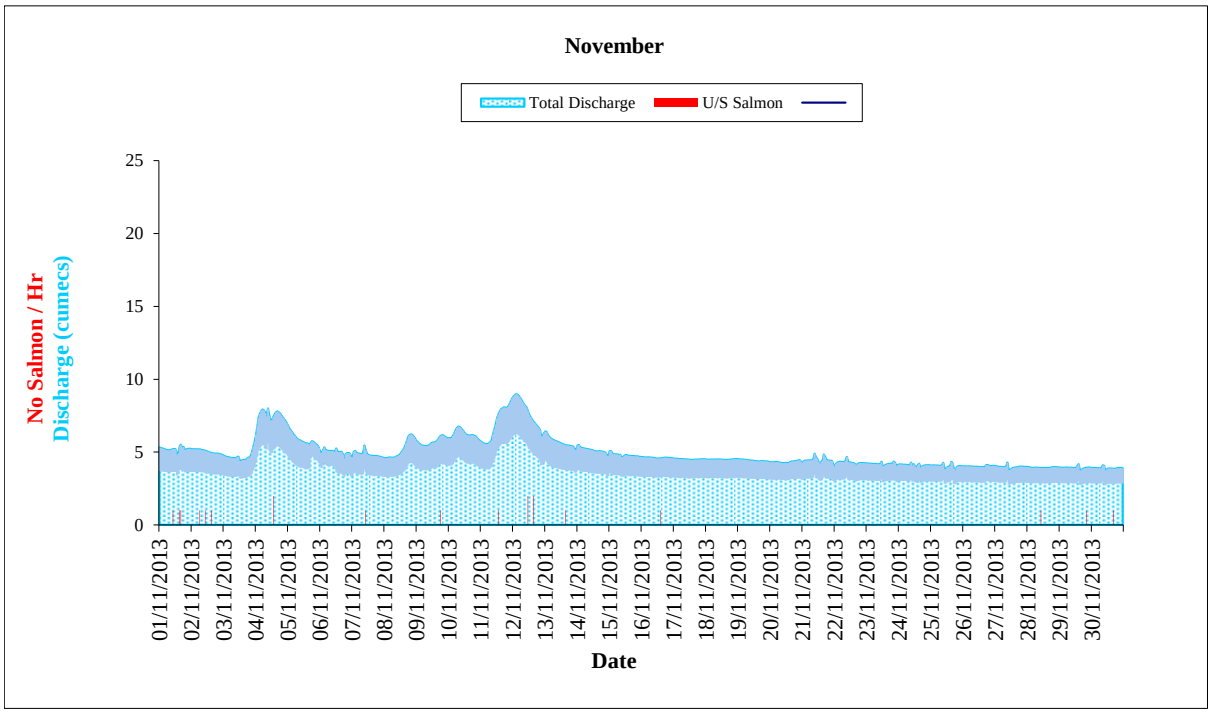
Appendix I Hourly data



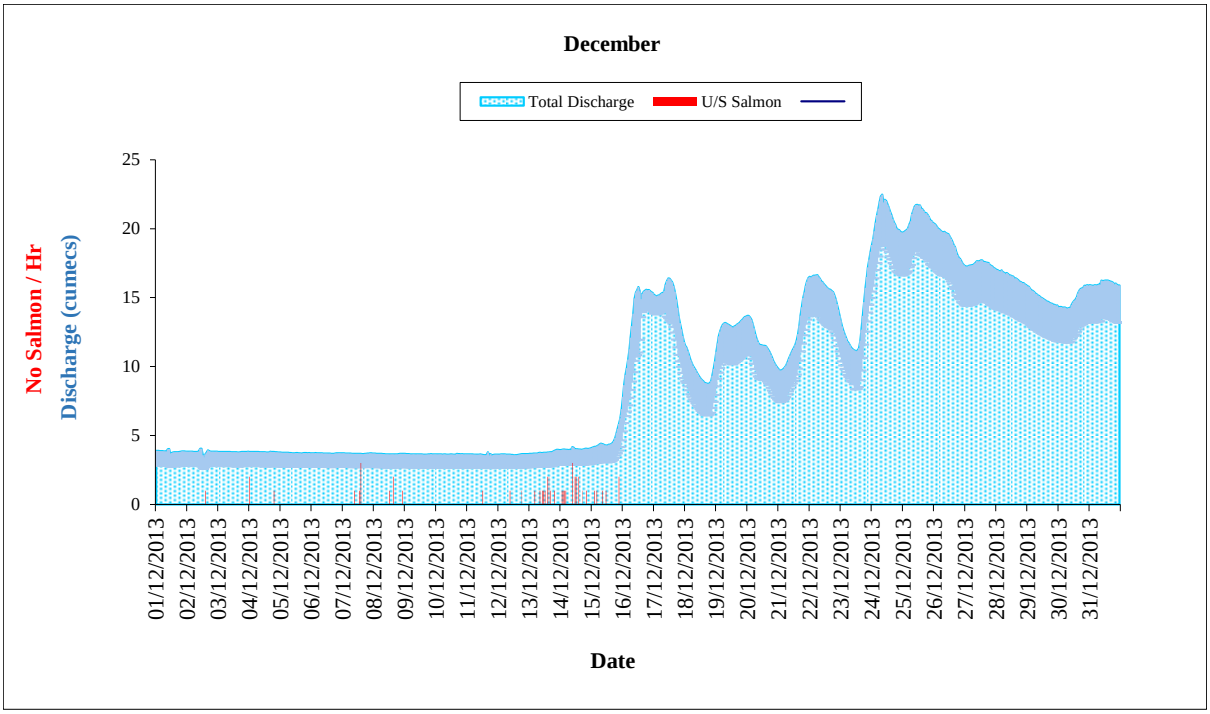


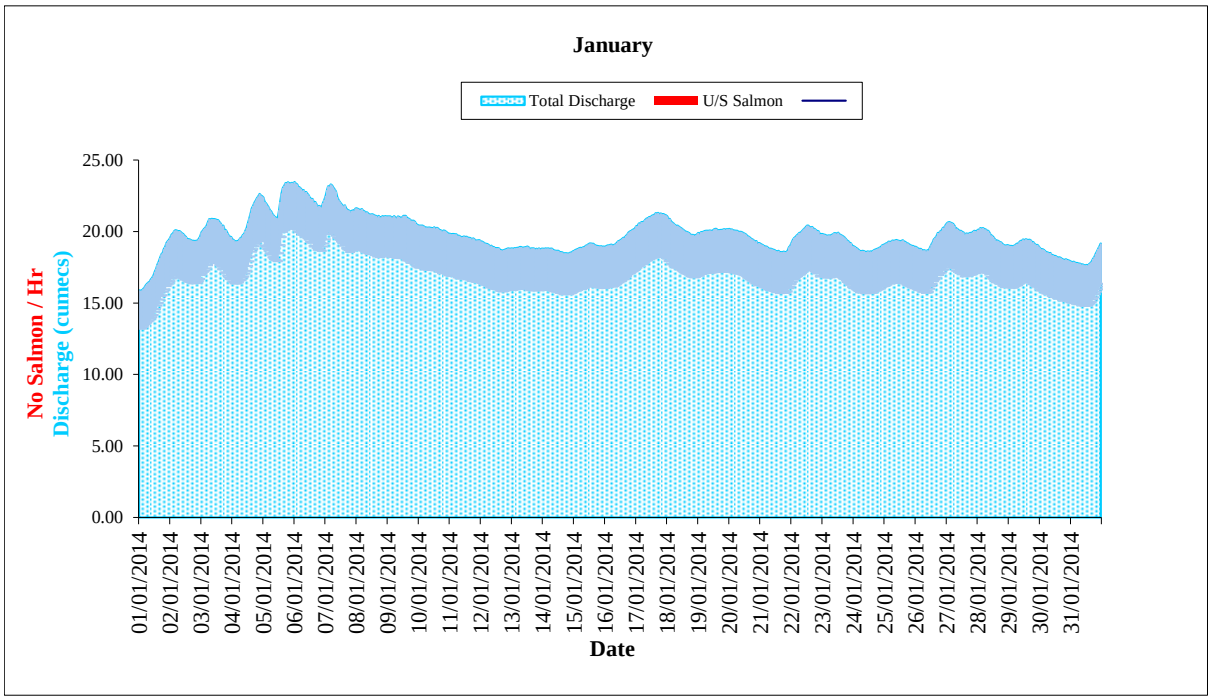
Appendix I Hourly data





Appendix I Hourly data





Appendix I Hourly data

The Game & Wildlife Conservation Trust

For over 75 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

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