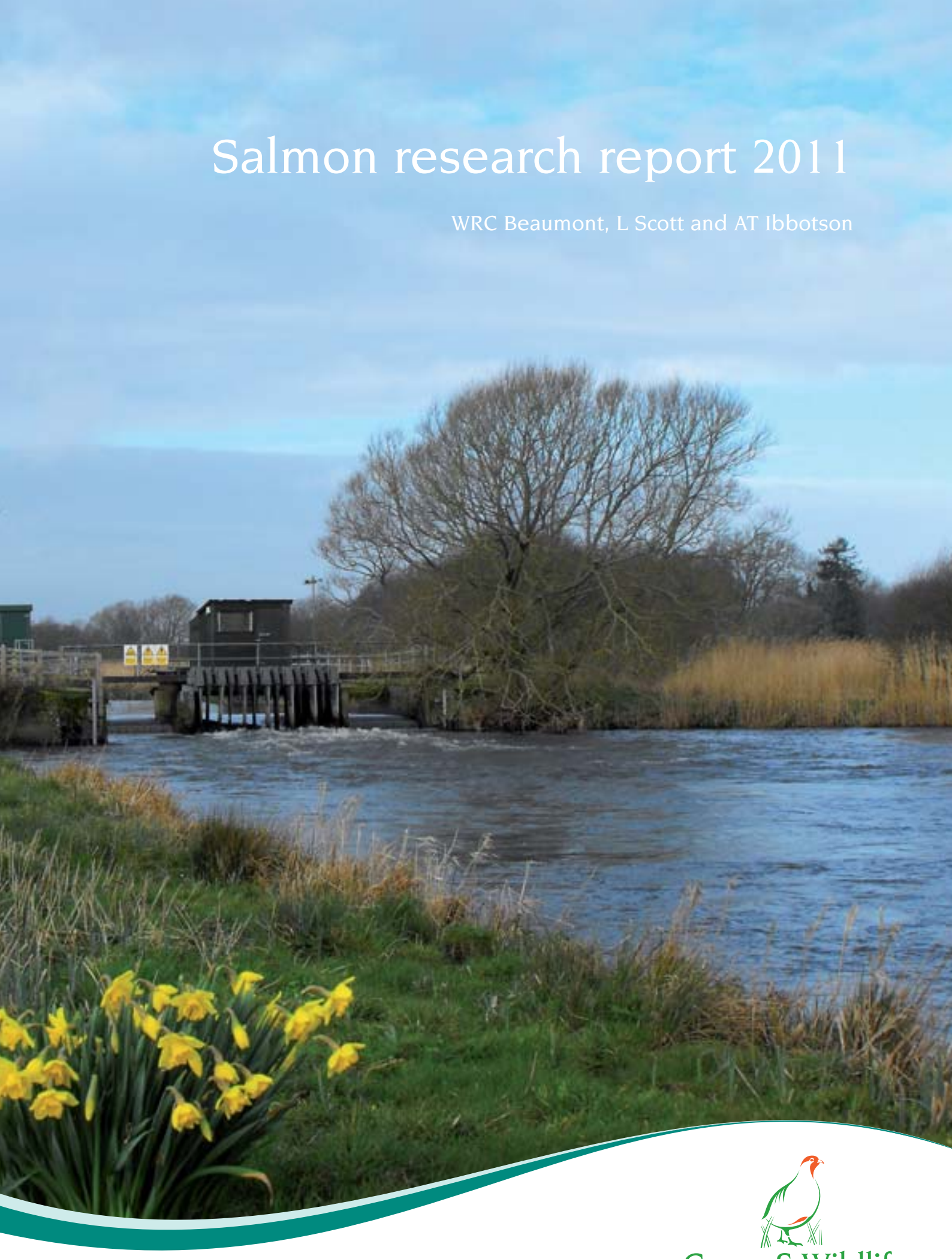
Salmon research report 2011

WRC Beaumont, L Scott and AT Ibbotson



www.gwct.org.uk/salmonreport

Game & Wildlife
CONSERVATION TRUST

Contents

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1. Abstract

Welcome to the 2011 *Salmon research report* from the Game & Wildlife Conservation Trust's Salmon & Trout Research Centre. This report gives a brief summary of the research carried out on the salmon populations of the River Frome, Dorset, over the past year. Highlights include:

- Parr numbers in the river in September 2010 were higher than average at 130,031.
- Higher than average numbers of autumn migrant parr went past East Stoke in 2010 and this could account for the 2011 spring smolt numbers being slightly lower than average at 9,787.
- The nett run of adult salmon moving up the river was 1,403 and is the highest since the major crash in numbers that occurred in 1991.

We continue with some long-term studies using the facilities at East Stoke, with research continuing on the impact of using Rotary Screw Traps to assess salmon smolt numbers. Such experiments need large samples of tagged fish to return from the sea and each fish can take three years or longer to come back. You need patience to be a salmon biologist! Some good news is the agreement with the Environment Agency that has just been announced, to use the well instrumented river to help decide whether hydropower stations installed on our river are 'fish-friendly'. We aim to set up the Passive Integrated Transponder (PIT) tag readers this year and start data collection in the autumn. Again patience will be needed. With the low winter rainfall we are unsure about the coming season and how well salmon will fare in 2012, but fingers crossed and on we go.

Professor Nick Sotherton
Director of Research

Acknowledgements

We are grateful for the support of the following organisations and people: the Freshwater Biological Association; the Environment Agency; the Centre for Environment, Fisheries & Aquaculture Science; the Atlantic Salmon Trust; the Salmon & Trout Association; the Frome, Piddle and West Dorset Fisheries Association; the Weston Foundation; the Valentine Trust; the Alice Ellen Cooper-Dean Charitable Foundation; Mr Anthony Daniell; Hon Michael Samuel; Lord Iliffe; Mr Rupert Harris; Mr Edward Gallia and family.

Bindon Abbey: The help and funding from the Lulworth Estate and the Salmon & Trout Association for these PIT tag detectors are gratefully acknowledged.

Finally, and importantly we are grateful to the many land and fishery owners on the River Frome that allow us access and enable us to carry out this research.

Front cover photograph: The GWCT Salmon & Trout Research Centre's salmon counter. Left: Head scientist Dr Anton Ibbotson, showing where the smolts swim through the fluvarium.

2. Introduction

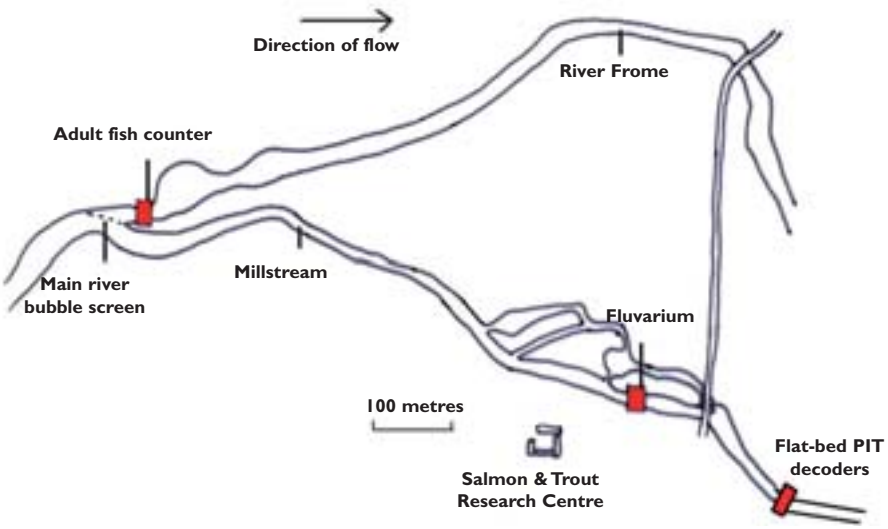
The adult salmon count data in this report represents the 39th consecutive year of the East Stoke counter's operation recording the upstream movement of Atlantic salmon *(Salmo salar L.)* in the River Frome. As such, it is one of the most comprehensive, long-term records of salmon movement in England and Wales.

Since 2009 the counter has been managed by the Game & Wildlife Conservation Trust (GWCT). However, the help and support of the Freshwater Biological Association (who own the site) is gratefully acknowledged.

The site at East Stoke has an unparalleled infrastructure in the river that enables us to monitor both the adult salmon migrating upstream and the juveniles going downstream. The site also allows the detection of small Passive Integrated Transponder tags (PIT tags) that we use to individually mark the 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 offer a unique opportunity to answer questions and conduct research that would be difficult to repeat at other sites. 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 river-site dependant factors that affect mortality and emigration.
- The interactions between the freshwater production of smolts and its impact on the marine production of adults.

Data from this research will enable intelligent management and conservation of the stock.

3. Salmon research report

The principle aim of the Trust's salmon research on the Frome is to estimate the population numbers of salmon at different stages in their life history (parr, smolt and adult). From this, we can work out the mortality between those stages and try to understand the causes of that mortality. Only by understanding what is going wrong can you hope to put it right.

To estimate the salmon population, we catch, mark and recapture some fish to estimate their population size.

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 numbers by marking some of the population and then catching them later on to see what proportion are marked. We use a variation of this method to determine the number of parr in the river, using Passive Integrated Transponder (PIT) tags as our method of marking.

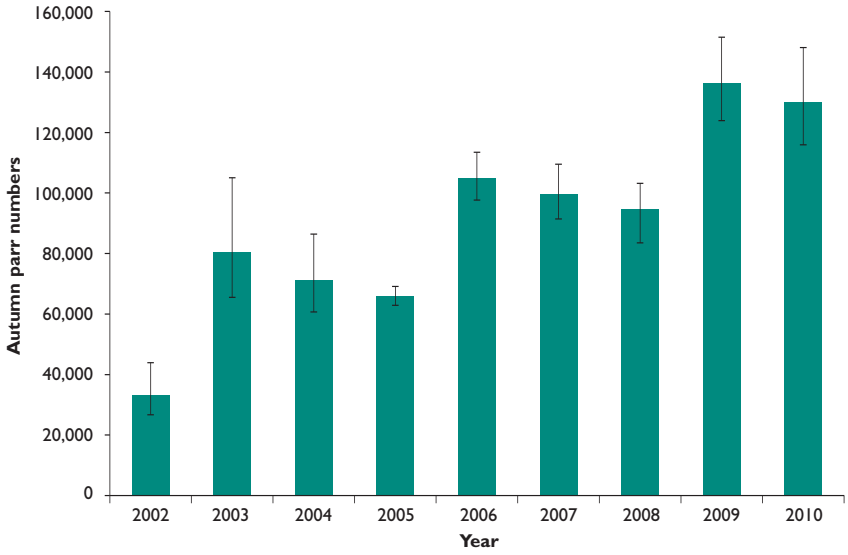
Each September for the past seven-years, we have electro-fished and tagged approximately 10,000 juvenile salmon (about 10-20% of the juvenile salmon population of the whole river) with PIT tags. These small tags (just 12mm long x 2mm wide – see below) are inserted into parr and enable us to individually identify the fish when they swim past our main detector at East Stoke as they go to sea.

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 return of the PIT tagged adult fish. There are also detectors mounted at the Louds Mill fish pass at Dorchester, at Tadnoll Mill on the Tadnoll Brook and the weir, hydro-turbine system and the fish-pass at Bindon Abbey.

This combination of autumn tagging, spring smolt counting and tag detection allows us to estimate 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 these data, so only data to 2010 can be shown (see Figure 2). These records, together with the records from the other PIT readers, are giving us valuable and unique information about freshwater survival rates. The data 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



Electro-fishing for salmon parr in September.

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).

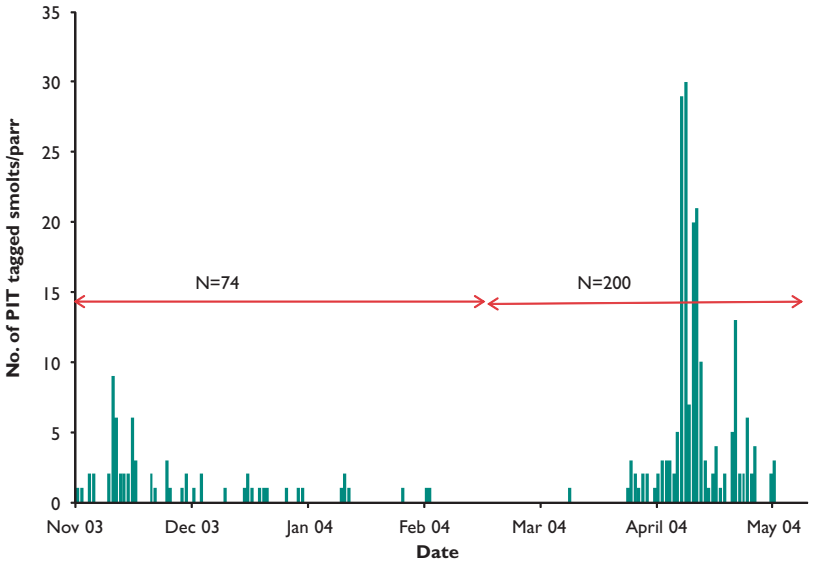


Figure 3

The autumn migrant run and the 'normal' spring smolt run 2003/2004

N= No of tags detected during period covered by red arrows

This phenomenon, although previously reported, was not fully quantified or explained. Our studies show that this movement is an active downstream migration ie. the fish are not just passively drifting downstream, but are unable 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 working with Government scientists from Cefas to further study the biology and behaviour of these fish. 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. In 2010 there were a very high number of these autumn migrants; about twice the long-term average (see Figure 4). Data for the 2011 run are still being analysed.

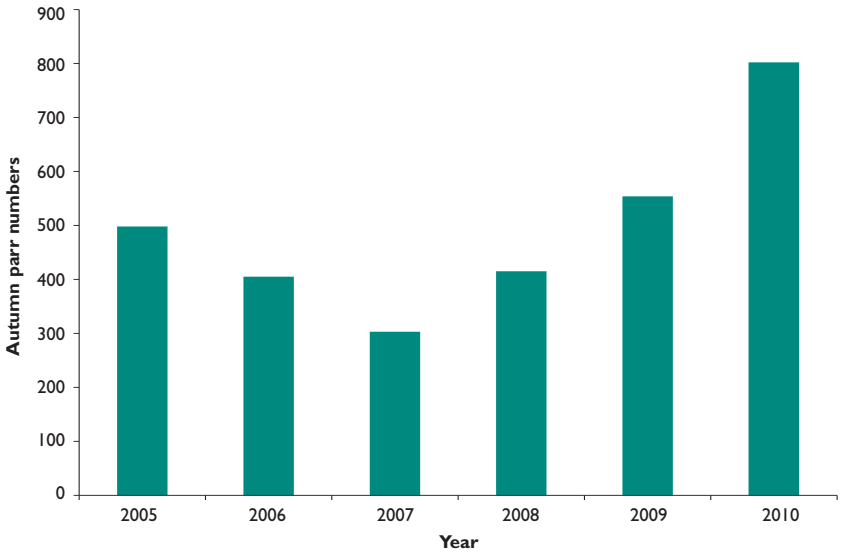


Figure 4

Numbers of tags detected during the 'autumn' run of parr

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

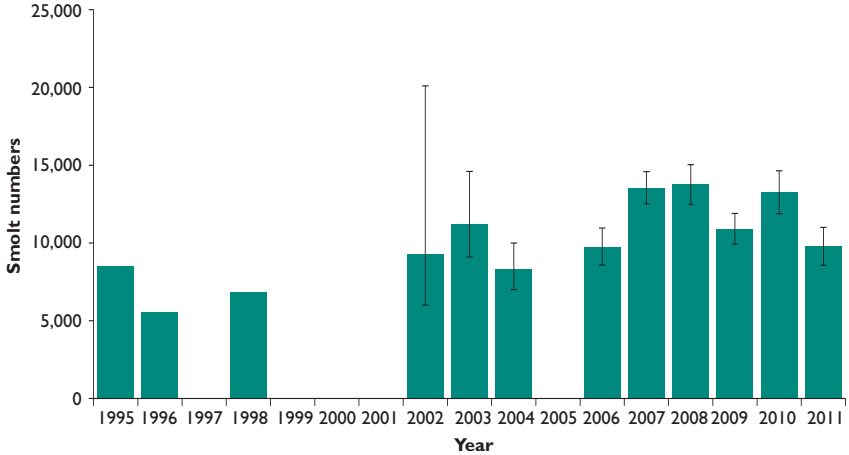
Smolt counting

Since 1995 we have been trying to count 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. Provision is made for adult fish to be able to negotiate the apparatus and additional studies have shown that the system does not affect upstream adult movement. Diversion rate in 2011 was very good at ~90%, with the low water level contributing to this high value. We direct the smolts down the millstream so that the fish can pass through the fluvarium tanks where (being a smaller volume of water) we can count them electronically. 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 improved, better estimates have been possible. Figure 5 shows the annual numbers (including the years with poor data) and it can be seen that since 2002 the data quality (with the exception of 2005) has been improving over the years.

The combination of autumn parr and spring smolt counts also allows us to identify the over-winter mortality of the fish. This has been found to be very high. We are using the data on individual fish location and habitat that we collected during the autumn survey to try to understand the causes of this loss.

Figure 5

Annual smolt estimate and (where available) confidence limits



The daily smolt migration data from 2011 are presented in Figure 6. Data are a total of PIT records from all the various detectors at East Stoke. Analysis of the data showed that a total run of 9,787 smolts emigrated from the river in spring 2011. This is lower than the average for the past few years, but may be linked to the higher than average number of 'autumn' migrants that migrated in 2010 (see Figure 4).

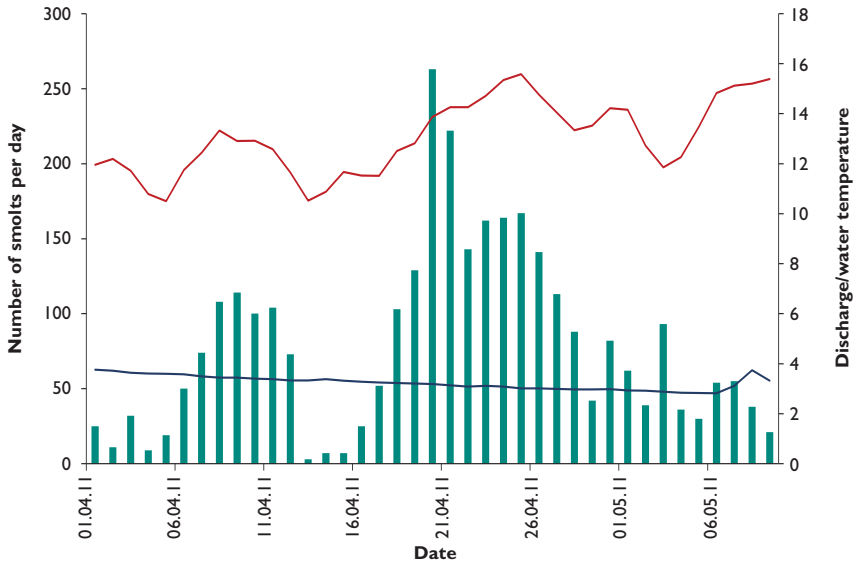


Figure 6

Daily count of smolts, mean discharge records and daily mean temperature

Total discharge

Water temperature

Checking migrating smolts for PIT tags in the fluvarium.

PIT tag readers have been installed at Bindon Abbey to check that salmon can still migrate upstream of the structure.

Bindon Abbey

In July we installed PIT tag detectors on the various hatches and fish passageways at Bindon Abbey. These will provide important information about the reactions of adult fish to the new Archimedes screw hydro-electric turbine that has just been installed. It will also improve our detection and information about the numbers and identity of tagged fish returning from the sea. The combination of the data from Bindon and East Stoke also gives us some interesting information about individual fish's migration speeds and behaviour. Table 1 shows some of the data collected so far.

We are hoping to also use the site to assess if there are any long-term effects on smolts that go through the turbine. Although the Archimedes type of turbine is thought to be 'fish friendly', few long-term studies have been carried out to confirm this.

TABLE 1

Examples of double detections from East Stoke and Bindon tag detectors, 2011

Date	Time	Tag no.	Tag reader	Direction	Fish speed (m/sec)	Species/place tagged	Year tagged
10.11.11	20:22:23	DC003AEE59	Main river PIT reader			Salmon/Muckleford	2009
11.11.11	00:52:53	DC003AEE59	Bindon Mill Hatches	Upstream	0.17	Salmon/Muckleford	2009
08.12.11	22:15:32	DC00396107	Main river PIT reader			Salmon/Woodsford	2009
11.12.11	23:15:35	DC00396107	Bindon Mill Turbine	Upstream	0.01	Salmon/Woodsford	2009
13.12.11	01:46:35	DC003ADEEF	Main river PIT reader			Salmon/Muckleford	2009
13.12.11	09:04:33	DC003ADEEF	Bindon Mill Fish Pass	Upstream	0.11	Salmon/Muckleford	2009
13.12.11	04:36:42	DC003A4757	Main river PIT reader			Salmon/Lewell Mill	2009
13.12.11	12:55:43	DC003A4757	Bindon Mill Hatches	Upstream	0.09	Salmon/Lewell Mill	2009

Rotary Screw Trap experiment

We are continuing our joint study with Cefas on the effect of Rotary Screw Traps (RSTs) on subsequent smolt survival. RSTs are widely used to trap and count migrating salmon smolts on many 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 PIT tagged fish to assess whether fish that have been trapped in the RST have higher marine mortality than those that have not. This work continues.

We are assessing whether fish that have been trapped in the Rotary Screw Trap have a higher marine mortality than those that have not.

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 the salmon and sea-trout that are caught, are tagged using a visible Floy tag and/or a PIT tag implanted into the body cavity of the fish. The fish are released and we then see if they are caught by the rods or pass the East Stoke detecting equipment.

Netting effort was very low this year and we accompanied the netsman on all of the seven netting occasions. Only one sea trout and one salmon were caught. Both fish were PIT tagged and the sea trout was floy tagged. The sea trout was caught and released by an angler in the lower Frome in August (identified from the floy tag) and the salmon was detected by the PIT tag readers at both East Stoke and Bindon Abbey in December.

Scale samples were taken from all the fish and these data are giving us valuable information at a time where catch and release angling is limiting the data we get on fish ages etc. Full details of the net caught fish are shown in Table 2.

TABLE 2

Salmon and sea trout caught in Poole Harbour netting 2011

Date	Species	Length (cm)	Weight (kg)	Floy tag/ PIT tag no	Comments/ condition (1 Good:5 Poor)	Age*
28 June	Sea trout	49	2.0	Red floy + DC00356102	Sea lice. Condition 1. Caught by angler 31.8.11 at Wareham, released back into river	2.2(SM)+
28 July	Salmon	62	2.5	DC00359943	Bad net marks (condition 3) and red vent. Released in lower Frome Detected East Stoke main river 21.12.11 7.50 Detected Bindon fish pass 21.12.11 11.35	1.1+

** SC= scale scarred: SM= spawn mark*

A sea trout caught and released from the Poole Harbour net. Note the small amount of net damage and the Floy tag (circled) by the dorsal fin.

4. Adult counter data report 2011

Data are collected by a resistivity counter connected to three stainless steel electrodes, mounted 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, rainfall and light levels are also collected at 15 minute intervals from 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 into 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.

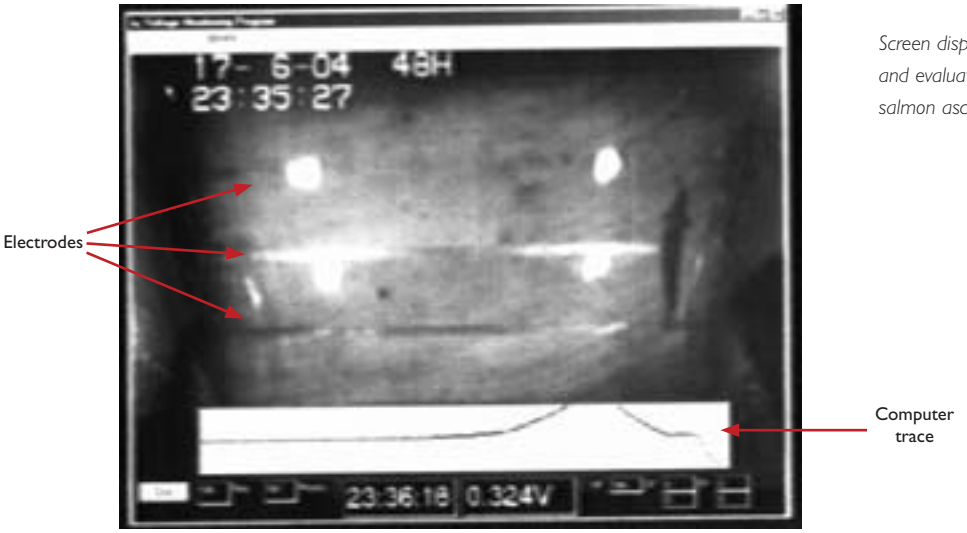
Data are presented either as total numbers ascending or descending or nett numbers ascending (ie. upstream minus downstream). Unless noted, all data are of verified counts.

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

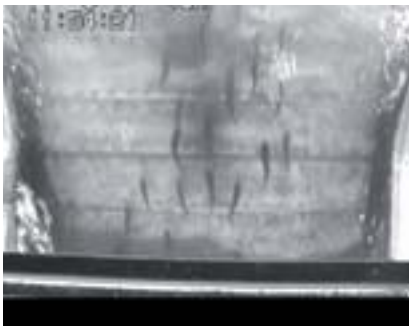
frame-grab and videotape analysis where we look at each fish. Only rarely are raw, unverified data used. An example of the computer verification system's display is shown below. A salmon can be seen on the video picture and the electrical trace is shown on the bottom section of the screen.



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

We were again fortunate this year in having few mechanical and electrical problems in running the counter. Over the year the electronic counter worked continuously and there was no waveform verification for only 12 days. The low water levels and lack of winter rain meant that turbid water resulting in either no video verification or images that were too poor for video viewing, only occurred for 78 days. There were only three days where no count verification was possible from either waveform or video data. Average accuracy of waveform interpretation was 137% for upstream and 94% for downstream records.

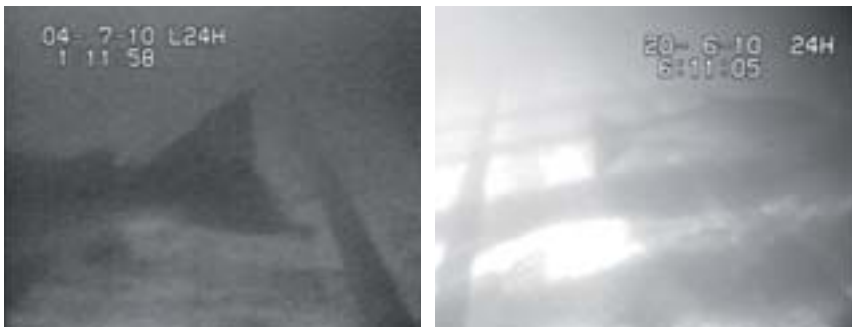
As well as verifying the counts the video also shows some intriguing pictures. One was an image of a pike with another pike crossways in its mouth descending the weir. The amazing thing is that both pike had been PIT tagged in a previous research study and we recorded both the tag numbers on the counter tag detectors. This year we also had large numbers of mullet and sea lamprey moving in the river in May.



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

The presence of large sea trout considerably influenced the over-count on the pc system with the traces from these fish being indistinguishable from those produced by salmon. The low and clear water conditions this year allowed use of the underwater side-viewing cameras that we are using to better differentiate between salmon and large sea trout. Around 100 good images were obtained and the results show that about 80% of images classed as salmon from the overhead video were correctly identified. A similar proportion of sea trout were also correctly identified. To estimate the potential variation from past recording methods we

noted all the sea trout (identified from overhead and side-view video) that would previously have been classified from the computer trace waveforms as salmon. The result showed a 6% difference in numbers.



(L-R) Side-view images showing an 88cm salmon and a sea trout on the weir.

Adult data 2011

Figure 7 shows daily counts together with mean daily discharge data. Monthly data from the counter are presented for 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.

Nett total for the year was 1,403

Figure 8 shows the annual nett run data (with pre-1985 data being corrected for down-counts) and shows that the total nett upstream count for the year was the highest since the major decline that occurred after 1991.

Figure 9 shows the 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

In 2011 we detected 25 PIT tagged adult salmon on the main river detectors. In addition one PIT tagged fish was rod-caught and unfortunately died below the counter. Fortunately, because the tag was recovered, we were able to add it to our list of returns. The returns were higher than in 2010, but are still lower than we would hope. The new PIT detectors at Bindon Mill should help us resolve the cause of the low numbers of detections and 'catch' any fish that may have been missed by the East Stoke detectors.

The PIT tags reported from Louds Mill are still being verified. We also detected three adult salmon tags on the PIT tag readers located on the Millstream: these fish will have by-passed the main river counter.

Fish size and sea-age

A total of 654 upstream migrating fish (48% of the nett run) were measured this year (Figure 10) with the largest being a fish of 110cm. Length data includes fish where only approximate length data are available. These data are from periods where there was some turbidity in the water and only approximate (± 5cm) length data could be obtained. In past years these data were not used leading to a loss of information that still has some value in assigning sea-age to the migrating fish. Data from fish below 45cm and fish that were obviously the same fish vacillating over the weir, have been excluded from the data set.

The length data obtained from the video records can be used to calculate the proportion of grilse and multi-sea-winter (MSW) fish migrating each month. 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 the 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. Figure 11a shows the estimated nett numbers of grilse and MSW fish for each month in 2011. Figure 11b shows the annual proportion of grilse and the numbers of grilse and MSW since 1996. These data may change as further refinement of the analysis is carried out.

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), air temperature and water temperature is shown. Graphs of the hourly data clearly show the clarity of detail available with the hourly time-base.

River flow

Figure 12 shows mean monthly discharge data (in cubic metres per second (cumecs)) for 2011 together with average (1966-2010) 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 5% of the time since 1966). These data are collated and calculated from Environment Agency records. The river discharge started the year within the median range (between Q1 and Q3 level) but rapidly dropped to below the 25%ile. By April it had dropped even further to below the 5%ile where (apart from a slight rise in August) it stayed until December.

Flows were so low that (unusually) summer fish migration in the river was affected by it. Hourly data (Appendix I) shows evidence of fish concentrating their movement upstream to times of higher flow.

Figure 13 shows that overall the mean annual discharge data for the Frome was the second lowest since 1966 and below even that of 1976.

5. References

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Month	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Total
Gross U/S	12	27	22	58	192	38	106	4	493	380	364	137	1833
Gross D/S	22	26	7	2	33	10	13	0	74	68	114	147	516
Kelts	5	16										88	109
Nett U/S	7	11	15	56	159	28	93	4	419	312	250	49	1403

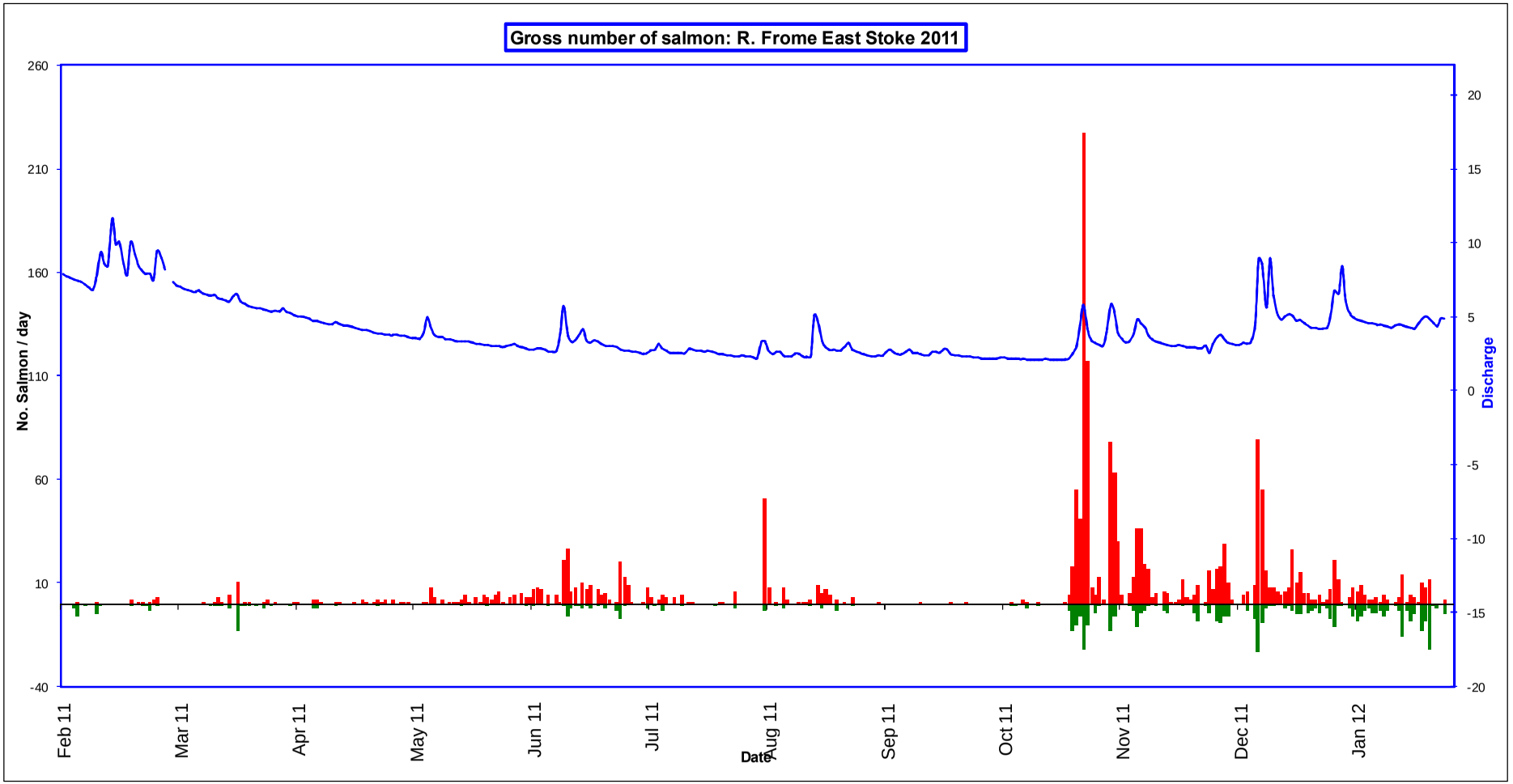


Figure 7 East Stoke Salmon Counter Data 2011

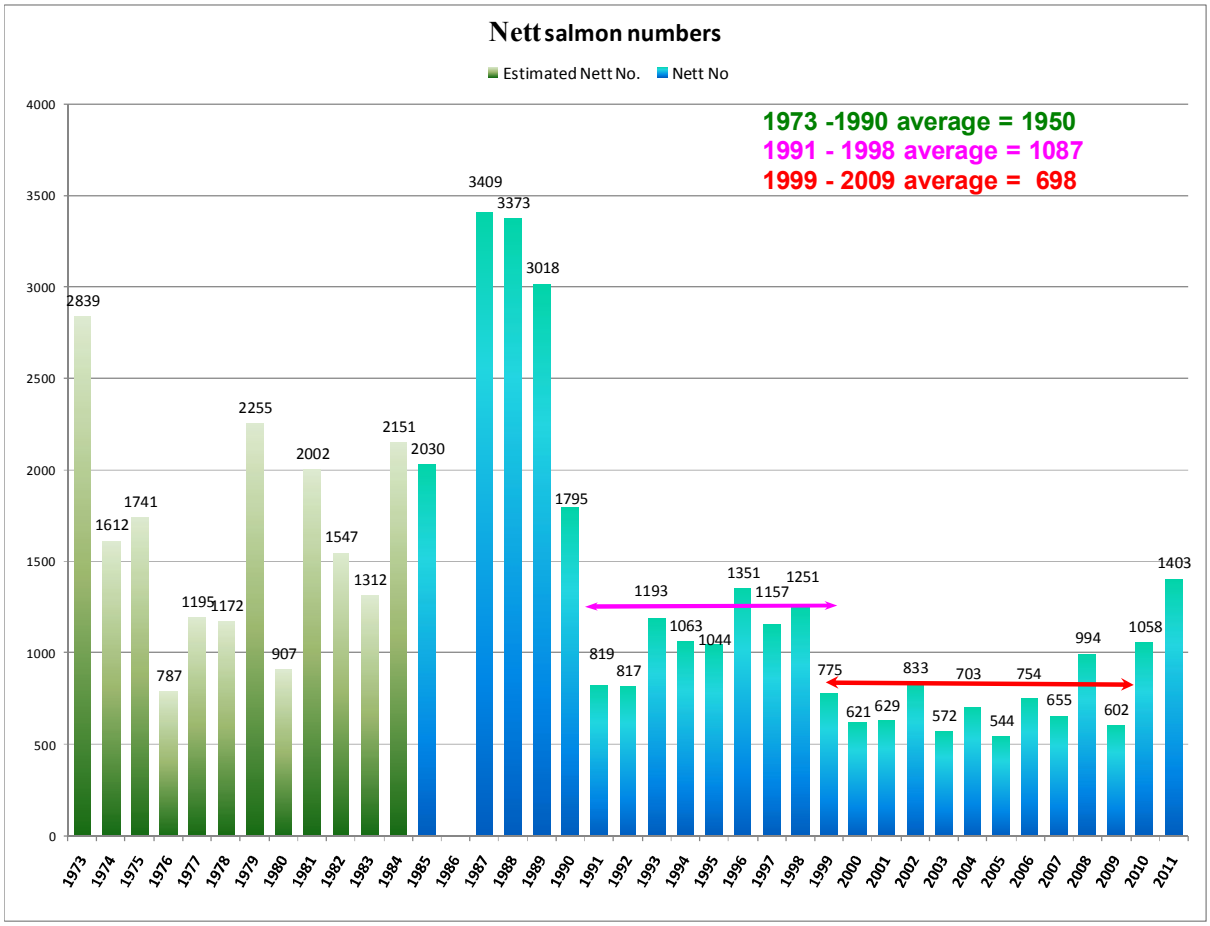


Figure 8 Annual numbers of salmon ascending the East Stoke weir

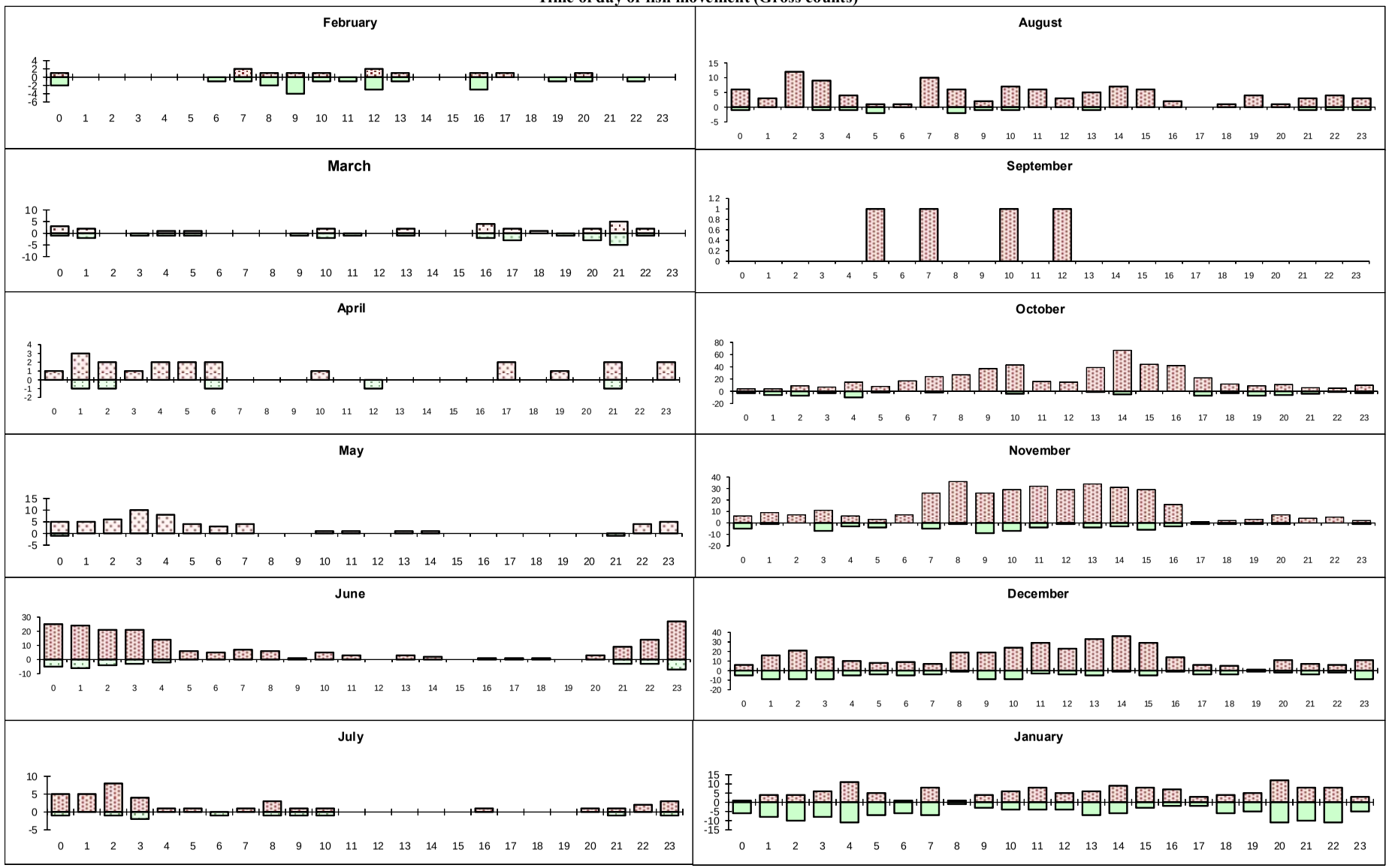


Figure 9 Time of day of movement (Gross upstream and downstream count data)

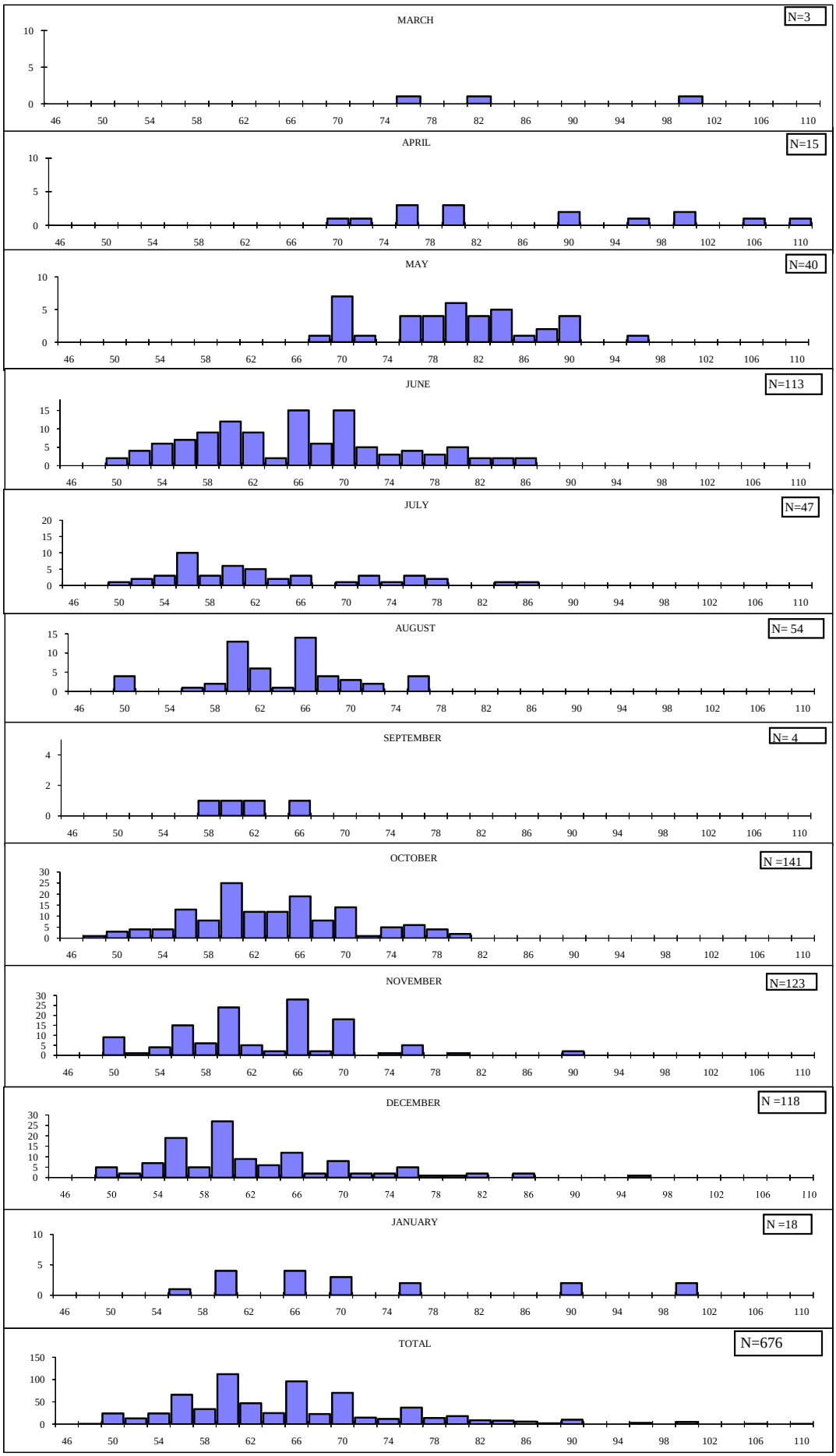


Figure 10 Length (cm) of upstream migrating fish each month

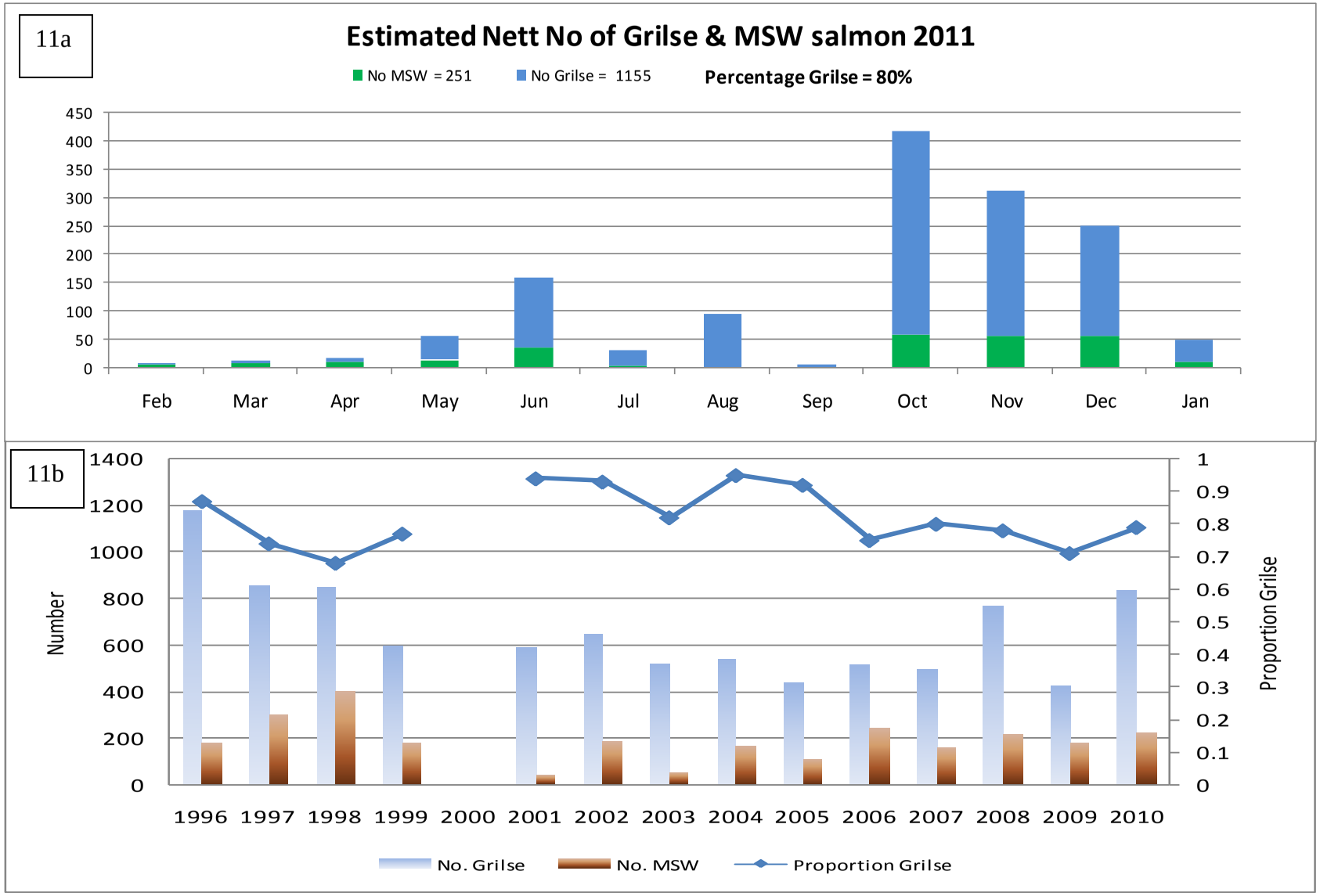


Figure 11a Estimated monthly number of Grilse and MSW fish 2011
Figure 11b Annual proportion and number of Grilse and MSW

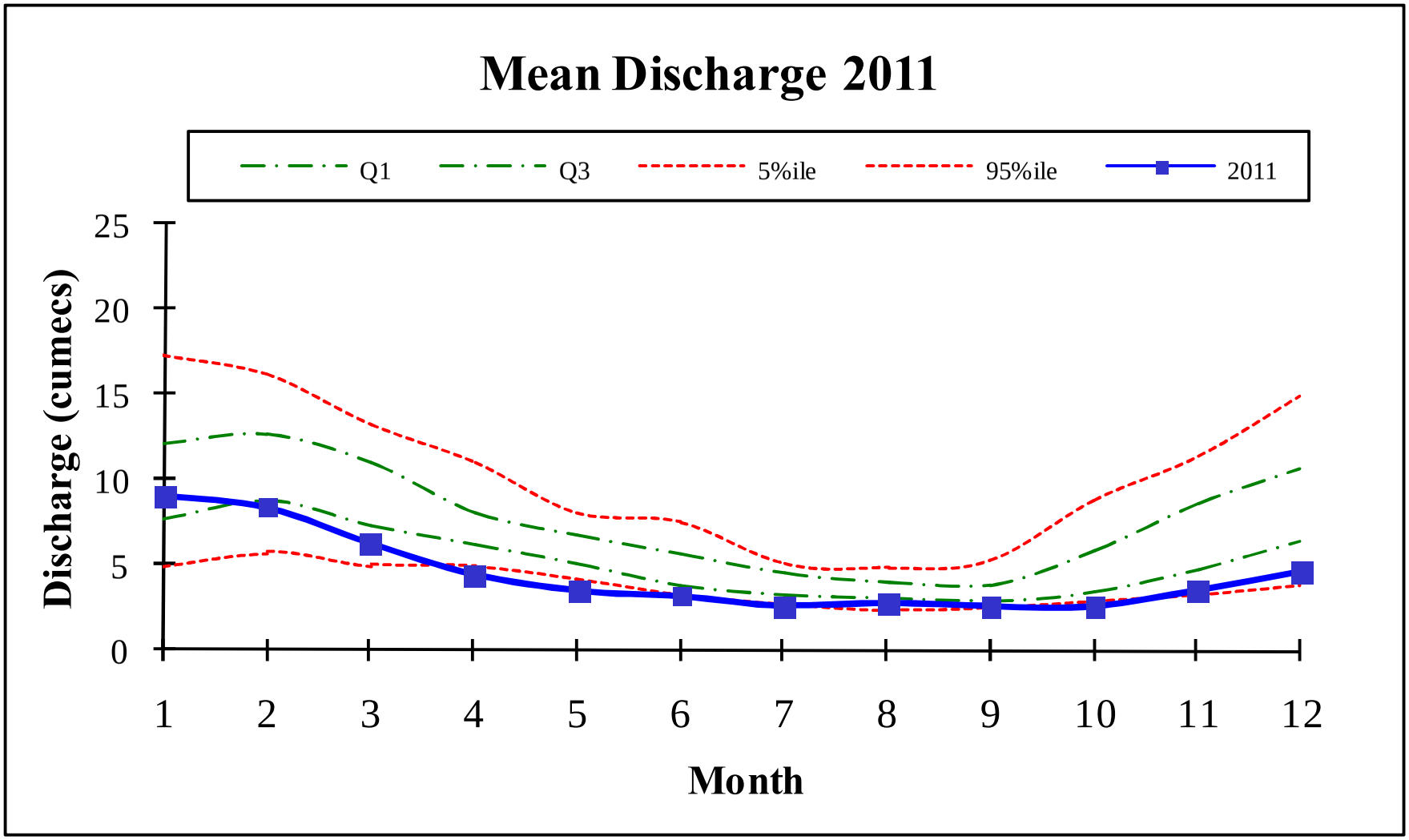


Figure 12 **Monthly mean discharge and long-term percentile data (Jan – Dec data)**

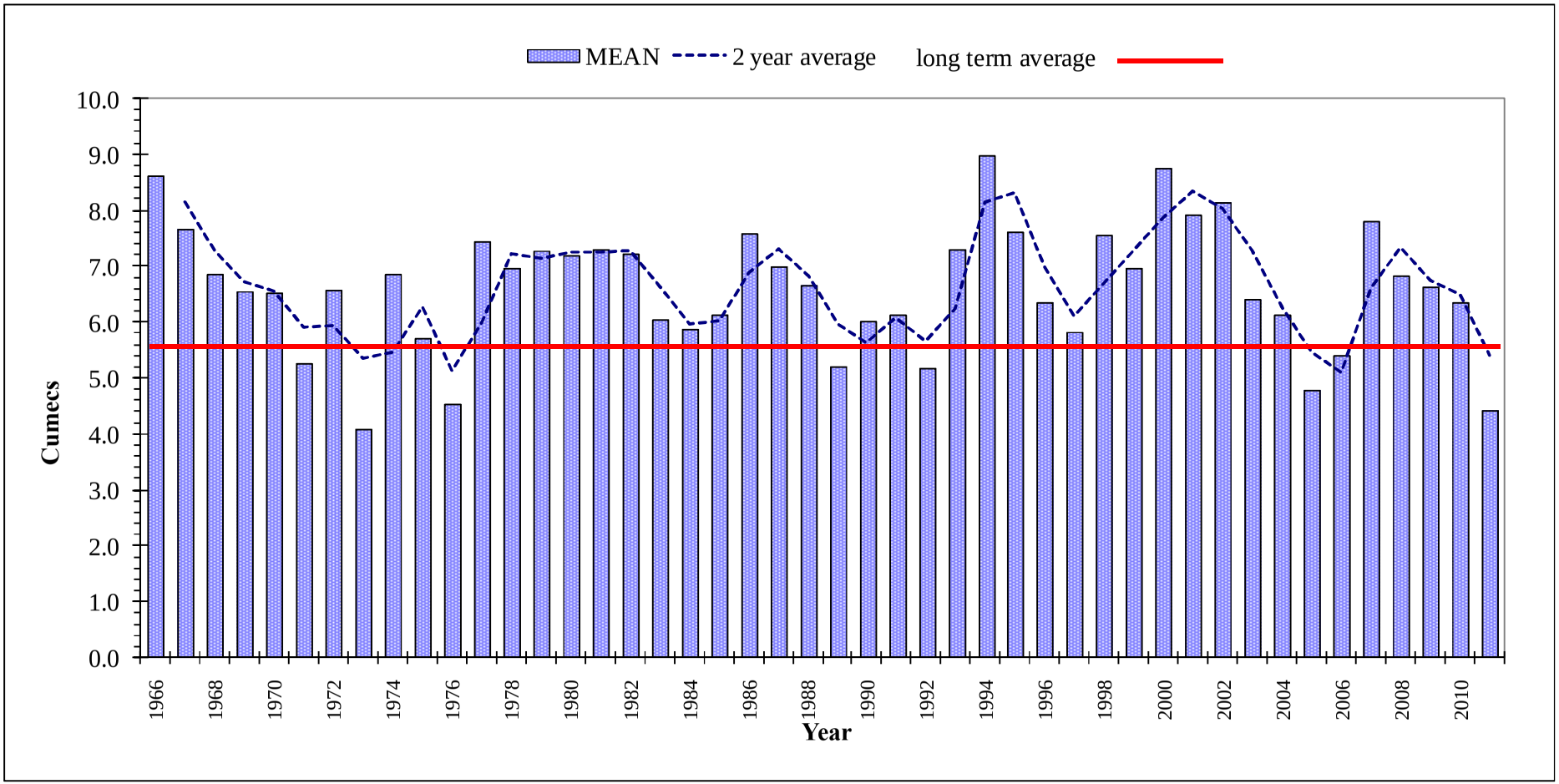
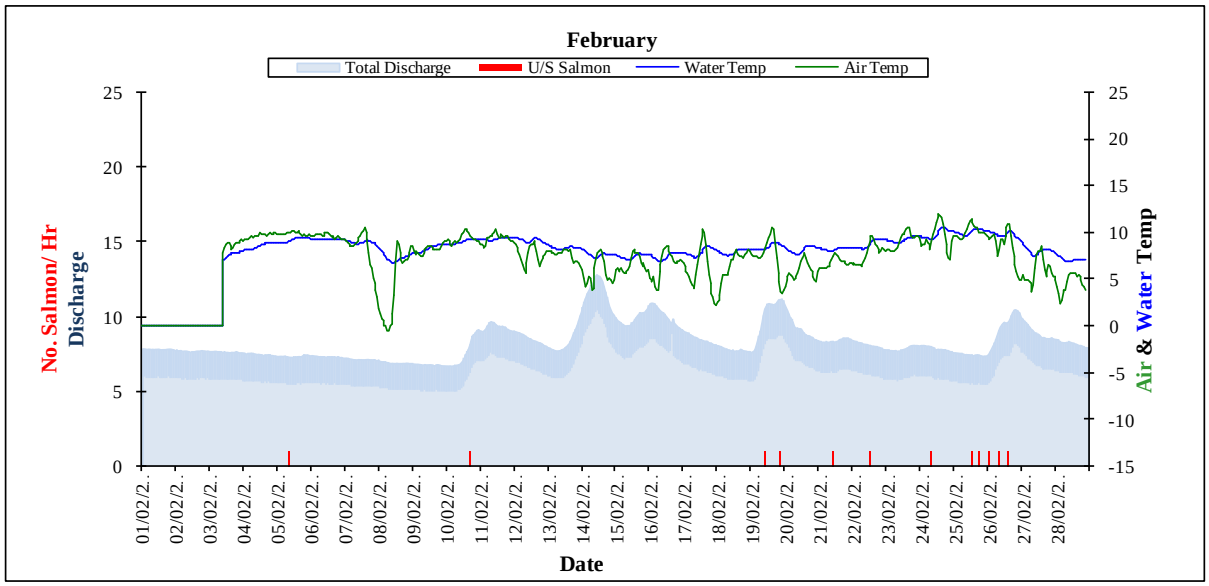
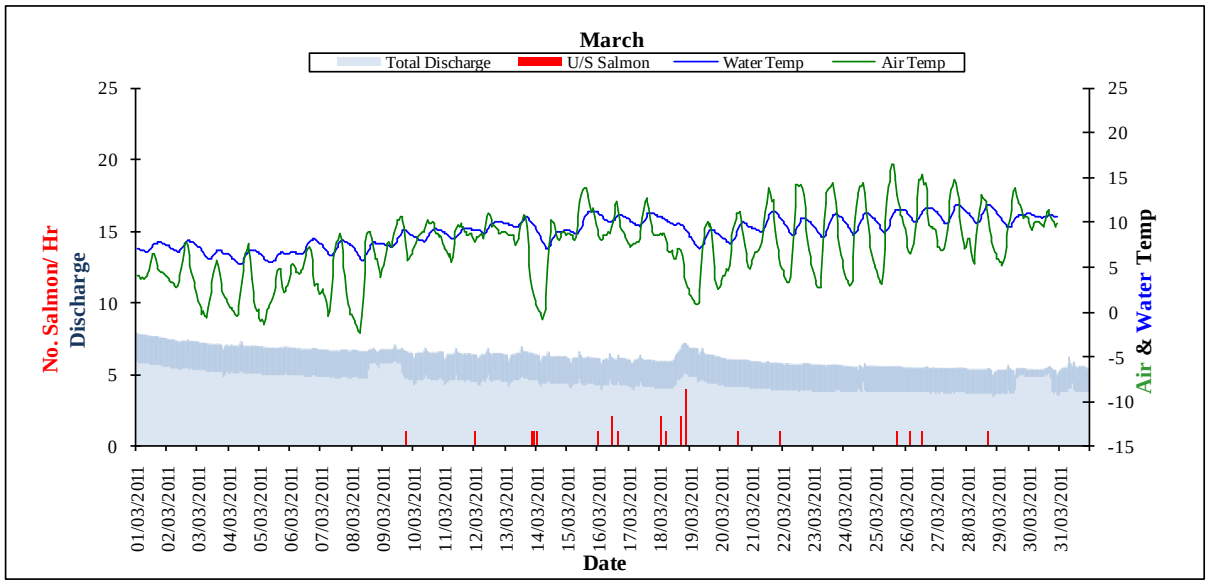
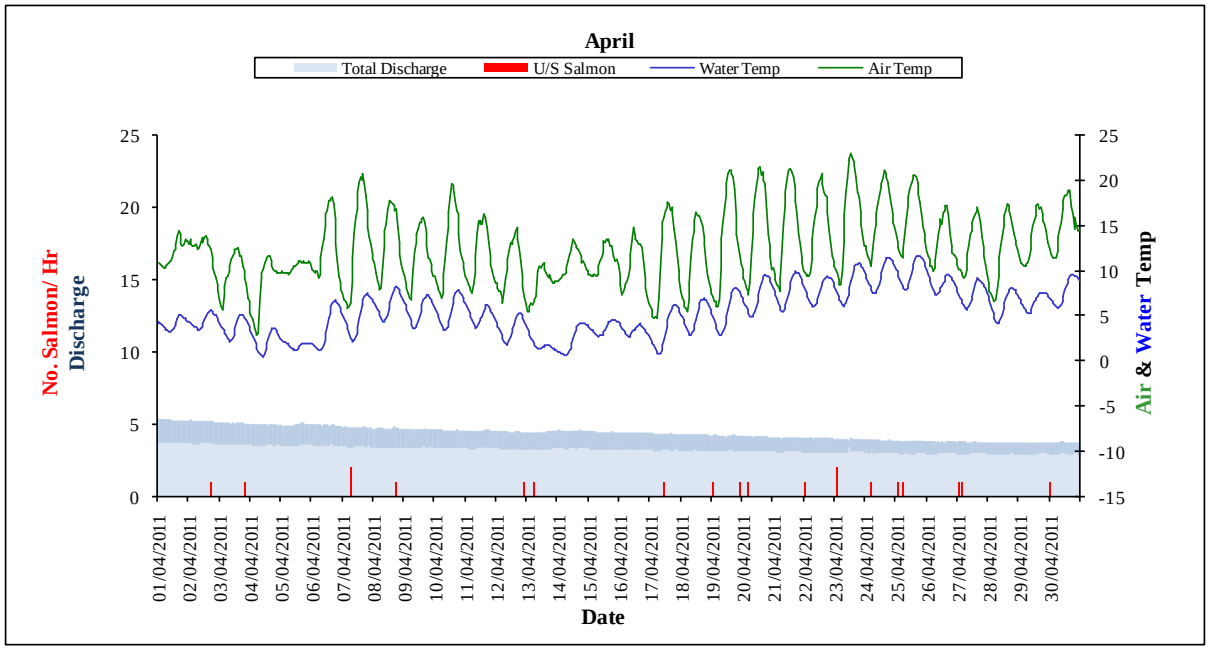


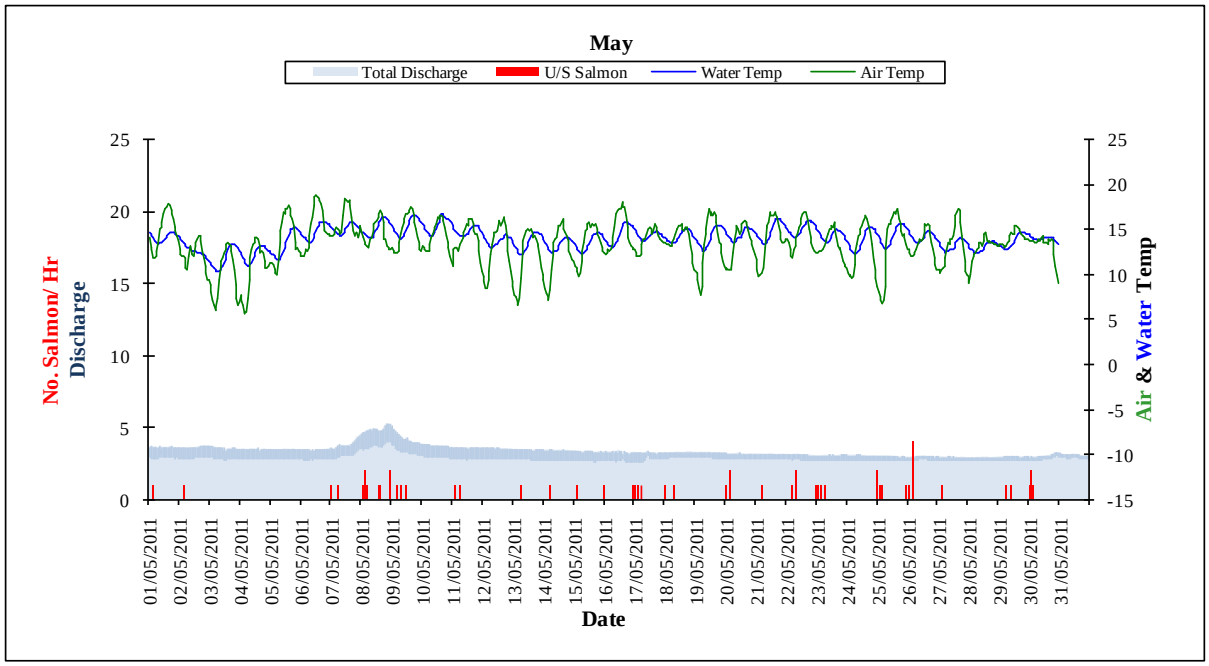
Figure 13 **River Frome long-term annual discharge**

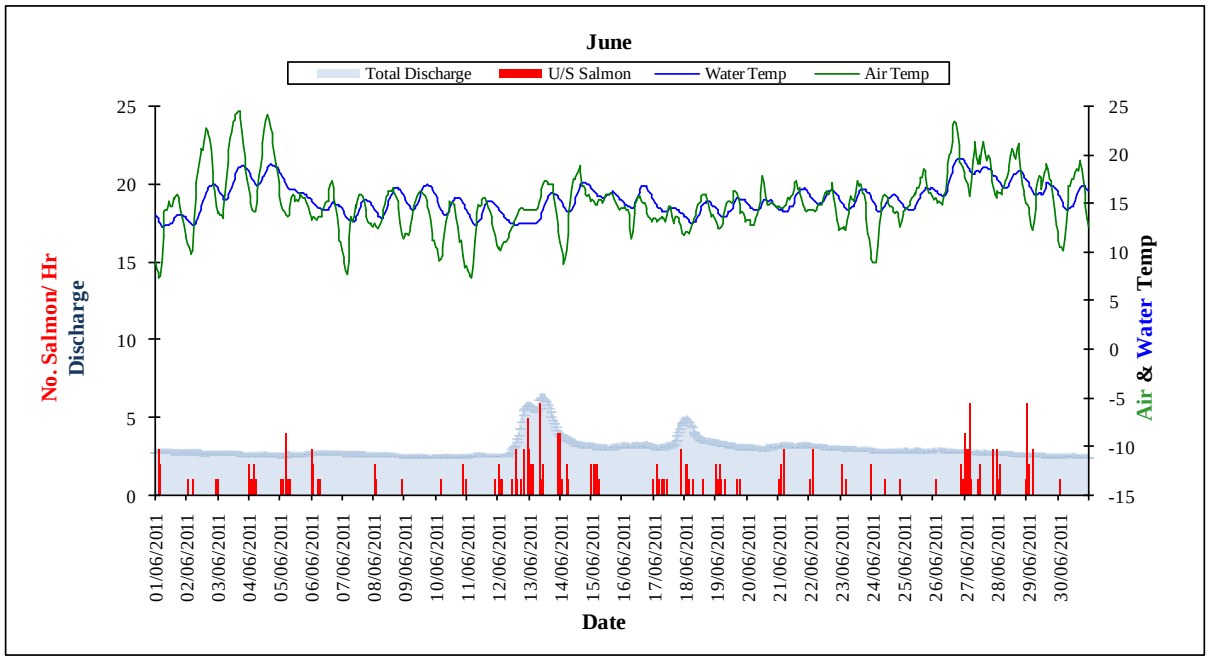


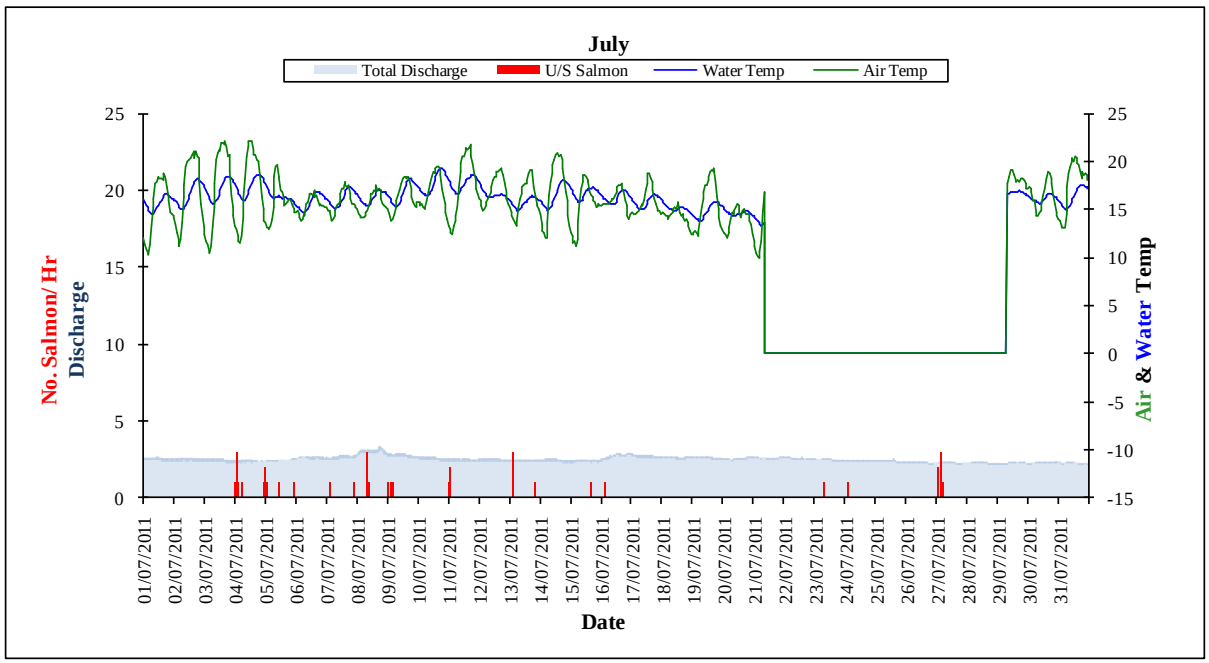




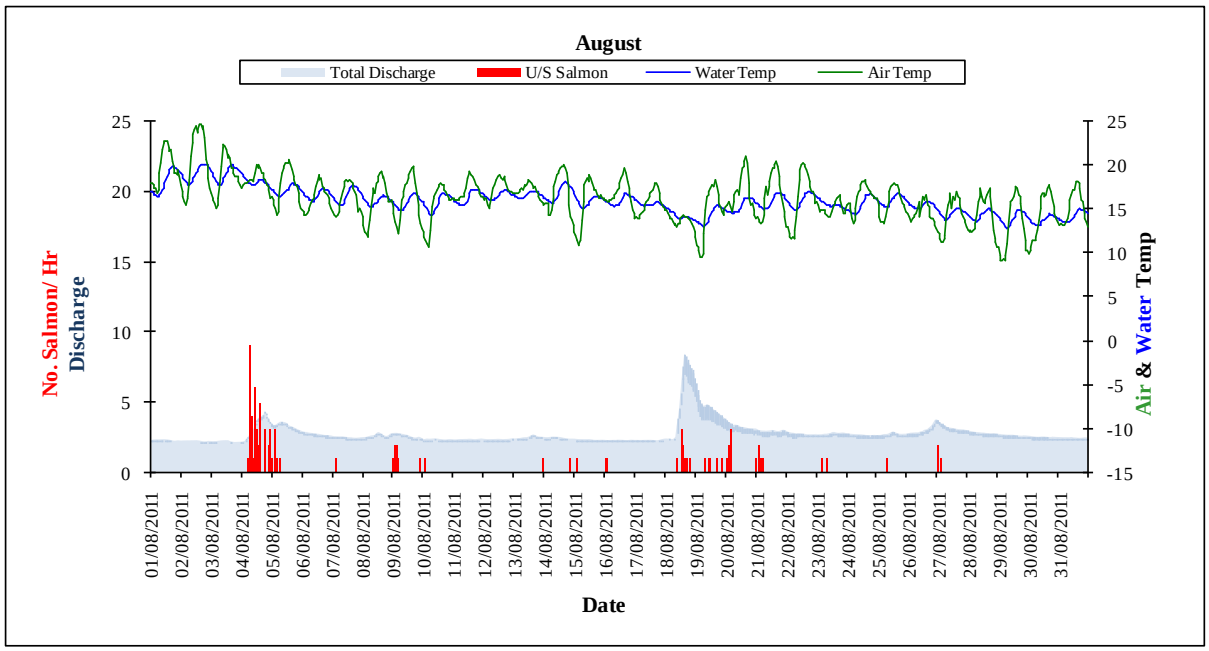
Appendix I Hourly data

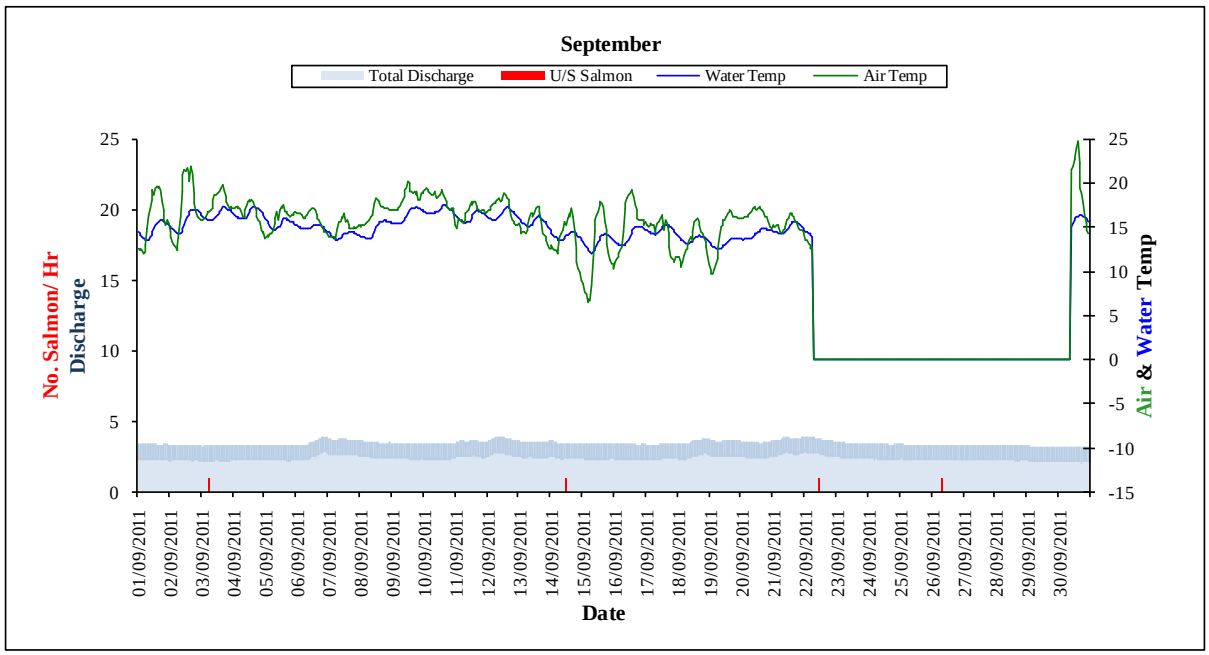


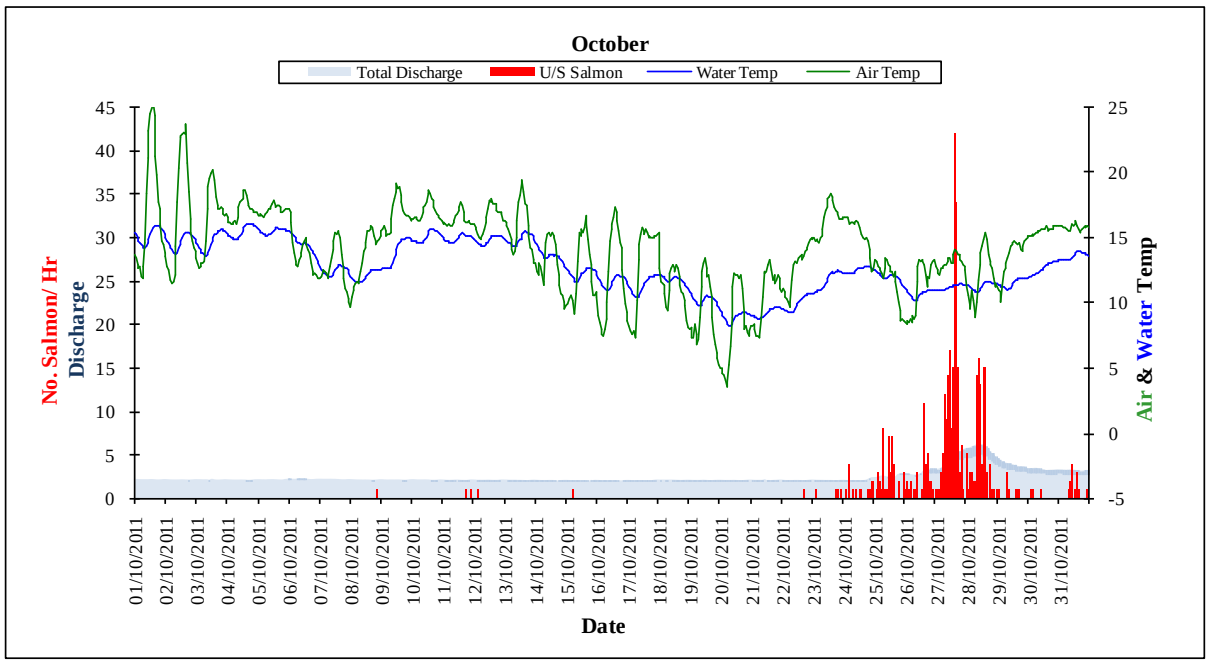




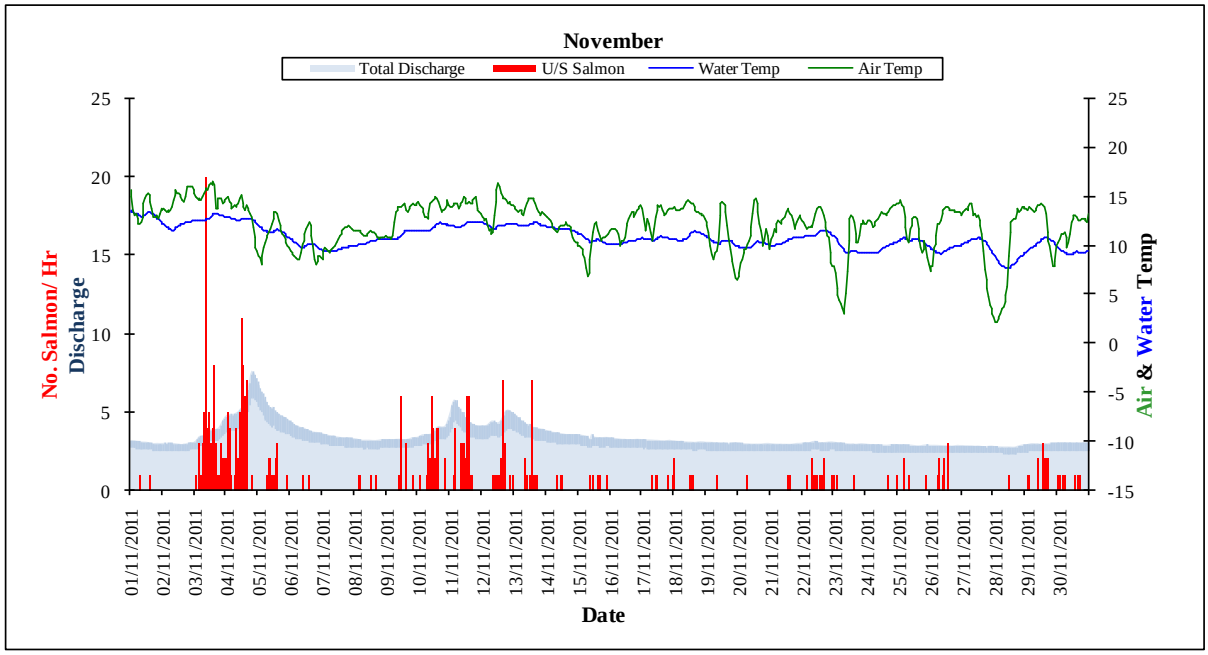
Appendix I Hourly data

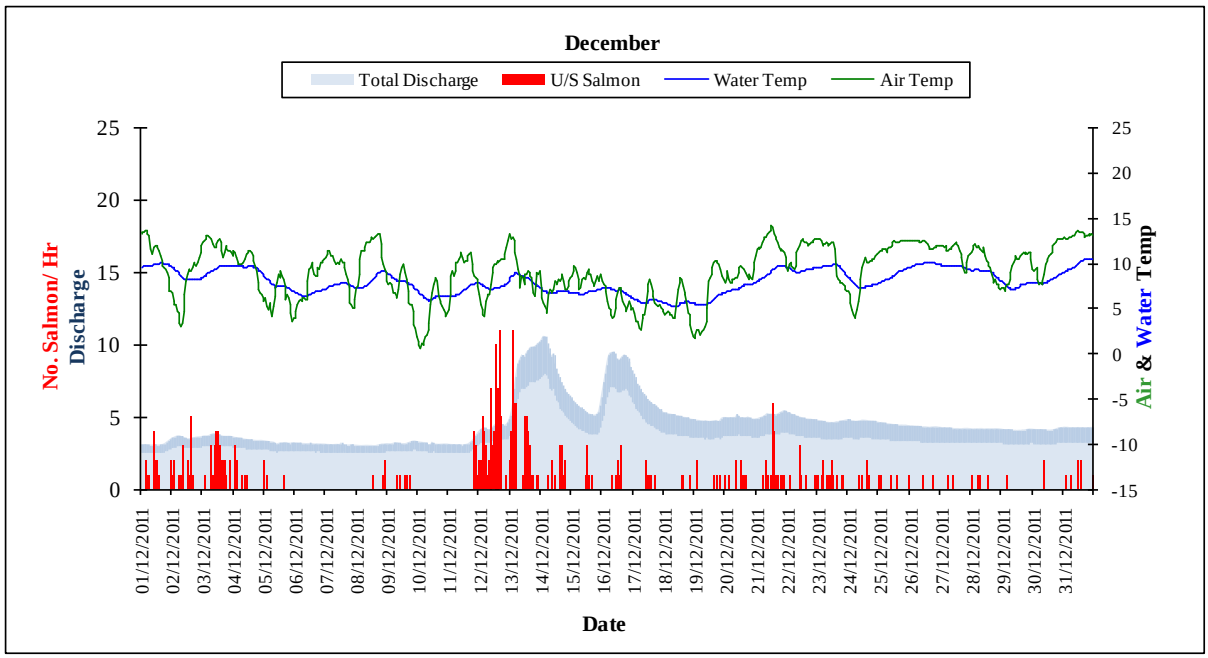


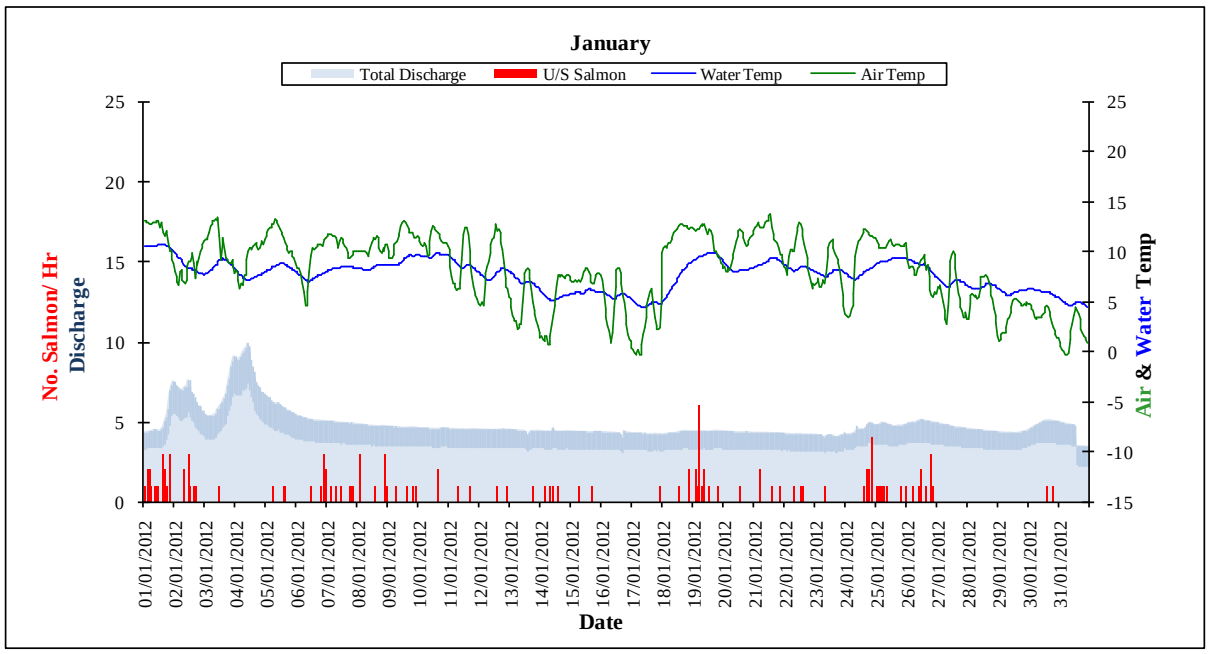




Appendix I Hourly data







Appendix I Hourly data

The Game & Wildlife Conservation Trust

For over 75 years our scientists have been researching why species like the grey partridge, water vole, 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
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