Salmon & Trout Conservation

Riverfly Census

CONCLUSIONS: Commentary

Salmon & Trout Conservation
KEEPING OUR WATERS WILD · EST 1903

HAMPSHIRE AVON

- The Avon's invertebrate community is under significant pressure from phosphate and sediment pollution.
- Phosphates in the river show a pattern of increasing levels upstream.
- Phosphates (orthophosphates) and suspended solids appear to be carried into the river at Stratford Sub Castle in the early part of the year with phosphates persisting for most of the year.
- Amesbury STW – Phosphate levels have an increasing upward trend. Suspended solids are high, erratic and increasing.
- Ratfyn STW – Phosphate levels are increasing albeit not so rapidly as at Amesbury STW. Suspended solids are also lower and more stable than Amesbury, although increasing in the past two years.
- Netheravon STW – Phosphates have some high peaks but no upward trend. River monitoring downstream of the STW recorded higher levels of phosphates than those at sites downstream.
- Apart from the weekly river monitoring at Stratford Sub Castle, EA monitoring is declining.
- There needs to be more in-river monitoring below major STW's.
- Apparently there are no plans to upgrade Amesbury or Ratfyn STW's.
- Chemical impact, as identified by the biometric SPEAR, was more pronounced towards the end of the survey period.
- SPEAR is an informative pesticide-herbicide-pharmaceutical indicator tool that could be extremely powerful if adopted into EA routine monitoring.
- Sediment (PSI) appeared to be associated with pesticides and phosphate, suggesting presence of agricultural and/or sewage associated sediment, such as agricultural run-off and/or municipal sewage in the Avon.
- There are high contributions of phosphorus from the upper catchment, from a combination of agricultural diffuse pollution, effluent discharges and some natural phosphorus loading.
- A nutrient management plan has been actioned to address poor water quality caused by phosphorus contributions from the upper catchment, but effort should be made not to add to this already 'high for a chalkstream' load downstream.

INTRODUCTION

The standard method for measuring water quality at a site is by recording the numbers and diversity of the freshwater invertebrate species at that site. Each species has a ‘fingerprint’ of its sensitivity, or tolerance, to different types of pollutants. Therefore, when a full species-level invertebrate survey is carried out (benchmark), water quality parameters can be determined.

Invertebrate benchmark surveys have been carried out at five sites during spring & autumn over the past three years (2015 - 2017) by Salmon & Trout Conservation. These surveys and the associated biometrics (Sediment, Phosphorus, Flow and Chemicals) in relation to the Avon’s invertebrate community are discussed. As this data is showing a serious decline in the water quality of the Upper Avon, we are looking for possible reasons for the decline to instigate the necessary changes that will help the river recover.

To better understand what is happening, we have compared our benchmark data with water quality measurements collected by the Environment Agency (EA), more specifically in regards to phosphorus and suspended solids where possible. Water quality is monitored at a number of sites by the EA and is directly influenced by discharges from large Sewage Treatment Works and other releases to surface and groundwater. The Avon is predominantly fed by chalk aquifers, where a large proportion of biologically available phosphorus (orthophosphate) is removed from groundwater. There is a shift in geology to upper greensand aquifers above the confluence of the Avon’s East and West branches. These aquifers do present a natural element of phosphorus loading to the river through the groundwater, but it is important not to overlook the fact that there is an anthropogenic contribution being added on top of the natural load.

This report focuses on the Avon below the East and West confluence and above Salisbury. Site locations can be seen in the map below and are evaluated in an upstream direction (Fig. 1).

BIOMETRIC INTERPRETATIONS

Table 1: Cumulative Annual Mayfly & Overall Riverfly Species Richness for Stratford Bridge 2015-2017

	Stratford Bridge		
	2015	*2016*	*2017*
Cumulative Annual Mayfly	8	7	3
Cumulative Annual EPT	23	25	17

At this site there appears to be a general declining pattern in fly life, with the cumulative annual number of riverfly species (EPT) dropping markedly from 25 in 2016 to 17 in 2017 (Table 1). Cumulative annual mayfly species richness also declined over the three years, achieving only 3 in 2017 (Table 1).

One of the major changes across the three-year period was the decrease of the siltation biometric PSI – a decrease in this metric means increasing sedimentation. The PSI score in spring 2017 indicated a greater impact of siltation on the invertebrate community than previous years, borderlining on the moderate impact category (Fig. 2). Autumn showed a similar increase where PSI shifted from the slightly impacted category during autumn 2015 to the moderately impacted category in autumn 2016 and 2017 (Fig. 3). Seasonal variation does occur whereby autumn biometric values typically demonstrate a greater impact than spring. Despite this, it is important not to overlook the indication of increased sediment impact on the Avon's faunal community. Interestingly, the large increase in silt levels has only just reached the EA 'RICT' prediction level for this site. A basic defect in this 'prediction' is highlighted, as it sets the river silt target at the 'moderately impacted' level.

The biometrics TRPI and LIFE also indicated a biological impact. For the phosphorus biometric TRPI during spring each survey year remained in the slightly impacted category, with a small peak in 2016 (Fig. 2). Autumn TRPI also remained in the slightly impacted category, but the 2017 score was closer to moderate impact and the 2016 score was closer to the unimpacted category (Fig. 3). In both spring and autumn 2015, the LIFE score was borderline unimpacted, indicating that pressure on the invertebrate community from flow was not significant (Fig. 2). However, during 2017 the score changed to one of slight impact and in autumn almost reached moderate impact (Fig. 3). Again, it is important to consider the seasonal variation, but it is evident flow was a greater stressor to the faunal community in 2017 than 2015.

Autumn *Gammarus* abundance also drastically declined from 1334 in 2015 to 210 and 183 in 2016 and 2017 respectively. This may be linked to an increase in pesticide-herbicide-pharmaceutical type impact as indicated by the SPEAR biometric, which was borderline poor in Autumn 2017. In the high abundance year (2015), the SPEAR score was high, indicating a minimal impact of pesticides on the invertebrate community (Fig. 3). This relationship is discussed in greater detail in the overall river summary (Fig. 24). Additionally, the increase in chemical impact may also be another contributor to the decline in fly life.

EA WATER QUALITY OBSERVATIONS

As there is no major sewage treatment works in this area, weekly EA data for phosphates (orthophosphate - OP) and suspended solids (SS) taken just downstream at Stratford Sub Castle, have been compared for this period (Fig. 4).

Table 2: Proposed maximum phosphorus concentrations (µg/l SRP) consistent with favourable condition of SSSI/SAC river habitat

River type			Headwater	River	Large river
High altitude (>80 metres)	Low alkalinity (<50 mg L^{-1} $CaCO_3$)		10	20	30
	High alkalinity (>50 mg L^{-1} $CaCO_3$)		15	25	40
Low altitude (<80 metres)	Low alkalinity (<50 mg L^{-1} $CaCO_3$)		30	40	50
	High alkalinity (>50 mg L^{-1} $CaCO_3$)	Chalk	40	50	50
		Clay	40	50	60

Joint Nature Conservation Committee. 2014. Common standards monitoring guidance for rivers. ISSN 1743-8160.

Current Common Standards Monitoring Guidance recommends the maximum concentration of biologically available phosphate for the River Avon should be 0.05 mg/l (Table 2)(JNCC, 2004). Concentrations of orthophosphate and suspended solids in the river have increased substantially since 2015 and are above the CSMG maximum level, with annual means of 0.06 mg/l, 0.07 mg/l and 0.09 mg/l for 2015, 2016 and 2017 respectively (Fig. 4). High concentration spike occurrence has also increased over this period for both OP and SS.

During 2016 and 2017, the concentrations are frequently above 0.1 mg/l OP and 10 mg/l SS (Fig. 4). These are biologically relevant levels that have been demonstrated to significantly affect Blue Winged Olive (*Serratella ignita*) egg survival to hatching (Everall *et al*. 2017). *S. ignita* spring abundance at this site during the census ranged from 284 (2015), to 49 (2016), to complete absence in 2017. Traditionally, spring is a sub-optimal time to assess *S. ignita* population numbers as their numbers peak in the summer months. However, more *S. ignita* have been overwintering as nymphs in the Avon and other chalkstreams in recent years. So, although the change in abundance may only tentatively reflect the stresses, it is still valid to look at. As the rest of the mayflies and wider riverflies do emerge in spring, the reduction of fly life overall could possibly be a result of similar interactions of OP and SS on their early life stages. However, potential impact from chemicals may also be a factor. Further research would need to be completed on the eggs of other riverfly species to verify such effects.

BIOMETRIC INTERPRETATIONS

Table 3: Cumulative Annual Mayfly & Overall Riverfly Species Richness for Little Durnford 2015-2017

	Little Durnford		
	2015	2016	2017
Cumulative Annual Mayfly	9	7	5
Cumulative Annual EPT	28	26	21

Over the three-year survey period, both cumulative annual mayfly species and EPT declined; 2017 was the lowest scoring year, with only 5 mayfly species (Table 3). This is a particularly low score, given the minimum target of 10 mayfly species agreed with the Environment Agency on the neighbouring chalkstreams. Cumulative annual EPT was also lowest in 2017 but still remained above 20 (21), so not catastrophic, although some of the mayfly niche may be being filled by opportunistic caddis species (Table 3).

During spring and autumn, the siltation biometric PSI consistently showed a slight sediment impact on the invertebrate community over the three years, with the exception of borderline no impact in Spring 2017 (Fig. 5 and 6). The phosphorus biometric TRPI was much the same, hovering around the slightly impacted category during both spring and autumn the entire survey period.

The flow biometrics (LIFE) mostly showed no impact on the biology, with the exception of a borderline slight impact in autumn 2015 (Fig. 6). The strongest pesticide impact was picked up during autumn 2016, whereby the invertebrate community demonstrated a moderate impact. Autumn *Gammarus* abundance reflected this, dropping from 3570 in 2015 to 594 in 2016 (Fig. 6). As the flow biometrics were not markedly different this year compared to other years it could be assumed that lack of dilution did not play a significant role and that higher concentrations of chemicals were present in the river at this site.

BIOMETRIC INTERPRETATIONS

Table 4: Cumulative Annual Mayfly & Overall Riverfly Species Richness for Ham Hatches 2015-2017

	Ham Hatches		
	2015	*2016*	*2017*
Cumulative Annual Mayfly	8	9	4
Cumulative Annual EPT	27	32	18

Ham Hatches showed a decline in fly life similar to Stratford Bridge during the three year survey period. Cumulative annual mayfly species richness in 2017 was less than half of the previous year and was significantly below the 10 mayfly species target agreed on the neighbouring chalkstreams. Cumulative annual EPT in 2017 had 9 less species than 2015 and 14 less species than 2016 (Table 4).

Again, the PSI biometric scores were low for 2017, indicating sedimentation was a considerable stressor on the invertebrate community. Both spring and autumn scores registered as moderate on the impact scale. During 2016 the PSI score demonstrated a slight impact in Spring and a moderate impact in autumn, whereas in 2015 PSI was relatively stable at the higher end of the slightly impacted category (Fig. 7 and 8).

For spring across the three-year period, the flow biometric LIFE showed a similar trend to Stratford Bridge, where no impact registered on the scale until 2017 (Fig. 7). Autumn demonstrated a greater impact, whereby all years were in the slightly impacted category. However, the impact was more pronounced in 2016 and 2017 (Fig. 8). As mentioned previously, it is important to consider that there is some seasonal variation between spring and autumn biometrics.

A moderate impact of phosphorus (TRPI) on the invertebrates was highlighted during spring 2017 compared to a slight impact in 2015 and 2016 (Fig. 7). During autumn 2015 Ham Hatches had an unimpacted TRPI score but exhibited a slight impact in 2016 and a borderline moderate impact in 2017 (Fig. 8).

The SPEAR index indicated a strong chemical impact on the faunal community at Ham Hatches in autumn 2017 (Fig. 8). SPEAR values for all the other samples did not highlight any concern regarding chemical impact. *Gammarus* abundance at this site appeared not to directly relate to changes in SPEAR, with autumn abundances of 8220, 96, 339 over the three years respectively.

EA WATER QUALITY OBSERVATIONS

This data was compared with EA water quality data recorded in the effluent at Amesbury Sewage Treatment Works (Fig. 9).

Phosphorus (P) levels taken once a month by Wessex Water at the final effluent of Amesbury STW showed a significant upward trend over a 6-year period. These measurements are taken prior to dilution in the river, currently the phosphorus discharge consent at this works is 1 mg/l (Fig. 9 - the dashed line). The annual mean phosphorus in 2017 (0.7 mg/l) was over double the mean phosphorus recorded in 2012 (0.29 mg/l). Generally, although P levels have been under the 1 mg/l consent level, there has been a steady overall increase in phosphate concentrations (Fig. 9).

No EA monitoring was conducted below Amesbury STW, so the dynamics of the STW discharge, once diluted in river, could not be compared. The only available in-river data was above the works by Queensbury Bridge (EA site name ‘HAMPSHIRE AVON AT AMESBURY’) and in contrast to the Stratford Sub Castle EA monitoring site, monitoring of phosphorus here was only taken once a month and less frequently during the last two years (Fig. 10).

The orthophosphate levels showed annual means of 0.09mg/l – 0.11mg/l between 2012 and 2017 (Fig. 10). Levels should be no higher than 0.05 mg/l (the black dashed line), according to the CSMG standard (Table 2). S&TC are working with the EA for a standard of 0.02mg/l on a nearby chalkstream, the River Itchen.

No in-river data for suspended solids after 2013 could be sourced, but suspended solids recorded at the output of Amesbury STW were compared with those at Ratfyn STW, upstream of Amesbury (Fig. 11). This data showed a marked difference between the STW’s, with much higher, erratic and increasing levels of suspended solids at Amesbury STW compared to those at Ratfyn, although there was an increase at Ratfyn during the past two years.

BIOMETRIC INTERPRETATIONS

Table 5: Cumulative Annual Mayfly & Overall Riverfly Species Richness for Queensbury Bridge 2015-2017

	Queensbury Bridge		
	2015	*2016*	*2017*
Cumulative Annual Mayfly	8	4	7
Cumulative Annual EPT	26	22	28

Similar to the other sites discussed so far, Queensbury Bridge also experienced a decline in fly life after 2015 (Table 5). However, EPT and mayfly species richness both increased again in 2017, achieving similar scores to 2015. The highest annual mayfly species richness score was 8, which is still below the 10 species target accepted for neighbouring chalkstreams. Autumn *Gammarus* numbers also showed a decline (584, 86, 45) and overall abundance in the samples was higher during spring (929, 125, 164) (Fig. 12 and 13).

The 2016 drop could have been the result of a combination of flow and sediment stress on the invertebrate community. There were greater stress signatures for both LIFE and PSI in Autumn, with PSI showing a moderate impact and LIFE changing from almost no impact to almost borderline moderate impact (Fig. 13). Despite the potential seasonal variation, it may have been that markedly lower flows this year resulted in less dilution and therefore a more pronounced impact of sediment. The SPEAR (pesticide-herbicide-pharmaceutical type impact) signatures also appeared to have a greater effect in 2016 than previous years, dropping from high to good in spring and good to moderate in autumn (Fig. 12 and 13). However, similar to sediment, this may have been a result of amplification from reduced dilution caused by lower flows. The close relationship between LIFE, PSI and SPEAR is demonstrated further in the overall river summary (Fig 22).

The phosphorus biometric TRPI only indicated phosphorus stress on the invertebrate community in the spring (Fig. 12). The site was borderline unimpacted in 2017 and slightly impacted in 2015 and 2016.

EA WATER QUALITY OBSERVATIONS

Queensbury Bridge site is downstream of Ratfyn STW. Final effluent phosphate levels at Ratfyn had annual means of 0.28-0.60 mg/l (Fig. 14). These means were generally lower than those found at

Amesbury STW (Fig. 9), together with a lower upward trend. Despite the lower average values, Ratfyn had more events at or above the 1 mg/l consent line.

Again there appears to be no EA data for either phosphates or suspended solids in the river below the STW.

BIOMETRIC INTERPRETATIONS

Table 6: Cumulative Annual Mayfly & Overall Riverfly Species Richness for Stonehenge 2015-2017

	Stonehenge		
	2015	*2016*	*2017*
Cumulative Annual Mayfly	7	5	7
Cumulative Annual EPT	27	23	21

Annual mayfly species richness at Stonehenge showed a similar pattern to Queensbury Bridge, only dropping slightly in 2016. The highest number of species found was 7, which is considered low for a chalkstream. Annual EPT showed a gradual decline in overall riverfly species over the three-year survey period (Table 6).

Increasing impact of flow on the invertebrate community, shown by the LIFE biometric, was found in spring and autumn over the three years, with the greatest impact detected in 2017. Lower flows in this year could explain the stronger chemical (SPEAR), phosphorus (TRPI) and siltation (PSI) impacts due to lack of dilution. SPEAR impact was particularly distinct, scoring well into the moderate category. PSI also showed a moderate impact during both spring and autumn 2017 (Fig. 15 and 16).

EA WATER QUALITY OBSERVATIONS

Phosphate (P) levels measured monthly by Wessex Water at Netheravon STW had a number of unexplained spikes but, unlike Amesbury & Ratfyn, there was no upward trend (Fig. 17).

Phosphates recorded in the river downstream of the STW are higher than those sites further downstream, with levels frequently exceeding over double the recommended 0.05 mg/l maximum chalkstream concentration (Fig. 18). Annual orthophosphate means at this location were all over 0.1 mg/l between 2012 and 2015. No orthophosphate data was available after January 2016.

Upavon is a site located much further upstream than the S&TC Riverfly Census biological sample sites on the Avon. However, It is interesting to look at the phosphate levels to understand how the downstream sites may be being affected by what is happening here.

Phosphorus measured in the final effluent of Upavon STW showed a substantial increase over the past three years; the annual mean of phosphorus in 2017 (0.84 mg/l) was over five times the annual mean in 2012 (0.16 mg/l). The off the scale measurements in October and November were 2.3 and 1.4 mg/l respectively, significantly over the consent level of 1 mg/l (Fig. 19).

Just upstream of Upavon, the river divides into the East and West Arms. These arms are fed with groundwater originating from upper greensand aquifers rather than chalk (Fig. 20).

Due to the nature of the upper greensand aquifer there is a natural phosphorus contribution to the river. However, this upper area is also largely impacted by phosphorus input from agricultural diffuse loads and effluent discharges, as described in the 2015 Hampshire Avon nutrient management plan.

(https://www.gov.uk/government/publications/nutrient-management-plan-hampshire-avon)

Data on each branch (just above the confluence) showed high levels of orthophosphates, with very high levels on the west arm, peaking in the summer months to around 0.3-0.4 mg/l (Fig. 21). The near-natural (reference) condition of rivers in catchments influenced by phosphorus rich geologies is debated, but a modelled background UGS baseflow quality of 0.154 mg/l for Upavon East, West and the Avon can be assumed (Environment Agency & Natural England, 2015). These sample sites are upstream of Upavon STW, so the already high levels of phosphates here would be combined with the previously demonstrated increasing amounts of phosphates coming in from the STW (Fig. 19). In-river orthophosphate levels downstream of the STW would have been interesting to look at, but there was no EA data for this part of the river.

BIOMETRIC RELATIONSHIPS

Where flow (LIFE) dropped at Stratford Bridge and Ham Hatches, sediment stress was greater, interestingly pesticide-herbicide and phosphorus (TRPI) stresses were also greater (Fig. 22). This indicates that sediment, aside to the stress it is in its own right, appeared to be associated with pesticides and phosphate. These findings suggested presence of agricultural and/or sewage associated sediment e.g. agricultural run-off and/or municipal sewage in the Avon during our sample period.

MAYFLY SPECIES

Cumulative annual mayfly species richness has been extremely variable over the three-year survey period, with no sites showing consistency in numbers (Fig. 23).

Richness in 2015 was the highest out of the three years, with no site achieving below 7. The highest scoring site was Little Durnford which had a mayfly richness of 9. Despite 2015 being the best achieving year no site reached 10 mayfly species, the chalkstream benchmark S&TC recently influenced on the nearby Test and Itchen rivers.

There was a marked drop in mayfly richness at Stonehenge and Queensbury Bridge during 2016, but the remaining sites did not drop below 7. Ham Hatches achieved the highest value of 9 mayfly species during this year.

In contrast to 2016, mayfly richness at Stonehenge and Queensbury Bridge improved in 2017, but decreased notably at the other three sites. These decreases may be a result of the upward trend of phosphorus and suspended sediment levels in the river. The high, erratic and increasing levels of SS from Amesbury STW, which is upstream of Ham Hatches, Little Durnford and Stratford Bridge, may explain why the 2017 mayfly species richness figures are so low. It is also interesting to note that at the two sites where large peaks in SPEAR occurred (Stratford Bridge and Ham Hatches), annual mayfly species richness dropped significantly in 2017, by more than half.

PESTICIDES

By inputting the Avon's species level results into a tool called SPEAR, the impact of pesticide-herbicide-pharmaceutical type signatures on the biology of the Avon can be assessed. The metric indicates presence and impact but does not differentiate which or how many are present. The SPEAR-based indicator is not used in current Environment Agency procedures but is a transparent and simple indicator of chemical contamination. SPEAR could be combined with molecular methods, with SPEAR used to diagnose the magnitude of contamination and relevant biomarkers applied subsequently to identify the type of contaminant (Schriever *et al*. 2008).

Gammarus spp. are standard test species in ecotoxicity testing in the UK (Gerhardt *et al*. 2011). One of the most significant observations through our sampling period was a widespread decline in *Gammarus pulex* abundance.

By plotting the SPEAR score against *G. pulex* abundance, a relationship is demonstrated whereby for most of the Avon sites an increase in chemical signature saw a drop in *G. pulex* numbers (Fig. 24). When the signature was above the WFD SPEAR threshold (dashed blue line) very few sites had abundances of over 500 *G. pulex*, which is the minimum target S&TC recently influenced the EA to adopt on the neighbouring Test and Itchen chalkstreams.

All the high peaks in *G. pulex* abundance occurred when SPEAR scores were below the WFD threshold, with the exception of Queensbury bridge. At this site, *G. pulex* numbers have been consistently low throughout the survey, but the SPEAR score was below threshold indicating other factors may have been influencing prevalence of *G. pulex* at this location.

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EA data sourced from Open Access Water Quality Data Explorer.

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