The invertebrate fauna of the River Spey

Analysis of data over a 39-year period

Craig Macadam

August 2020

Contents

Summary

This study has analysed the results of invertebrate sampling at six sites on the main stem of the River Spey. The data was sourced from the Scottish Environment Protection Agency (SEPA) and covers a 39-year period between 1981 and 2019. It is not complete however, with only one site, at Fochabers having samples for each of the 39 years.

Overall, the Invertebrate populations of the Spey appear to be in good health. The total number of riverfly species is stable or increasing slightly and most families show increases in abundance in recent years. The total number of families and species richness both also show slight increases over time. The species diversity is also generally stable, however slight declines are evident at Grantown and Fochabers.

There is evidence of a decline in abundance of a number of families during the 1990s however in most cases numbers have subsequently recovered. The populations of *Isoperla grammatica*, Brachycentridae and Glossosomatidae show variation in their abundance, particularly in the middle river. At Garva, the caddisfly Sericostomatidae appears to have colonised the site in recent years suggesting that it could be expanding its range upstream.

A number of biotic indices were calculated from the data which reveal that water quality in the Spey remains very good. There is some evidence of lower flows influencing the composition of the invertebrate population, which may also be leading to a slight increase in sedimentation, however the river is still minimally impacted by sediment.

A series of recommendations are made for future monitoring and investigation.

Introduction

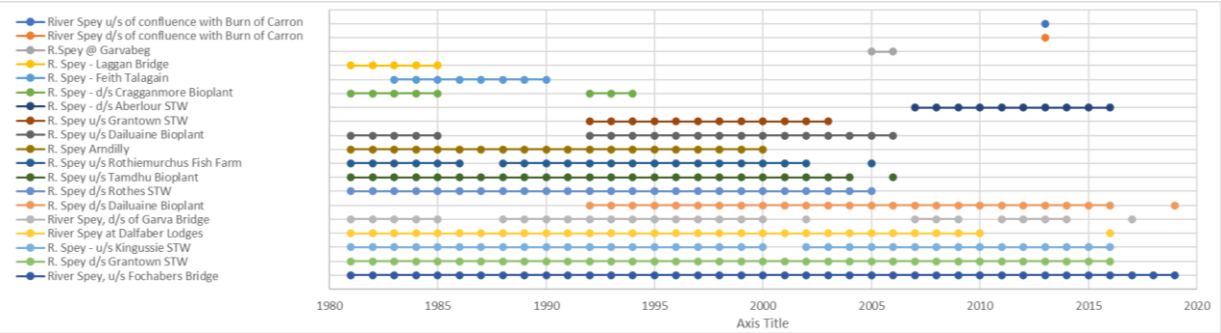
Following concerns about changes in the aquatic invertebrate populations of the River Spey, the Spey Fishery Board commissioned an analysis of historical data to determine any trends in species of importance to anglers, and whether there are any indications of changes in water quality or flow.

Invertebrates are at the heart of freshwater ecosystems. From tiny water fleas to stoneflies and caddisflies, these organisms are the lifeblood of rivers and streams and are a vital link in the aquatic food chain. By converting algae, plants and plant detritus found on the streambed into animal matter, they provide the primary source of food for fish and birds such as the Dipper. Any change to the invertebrate fauna impacts on the food web and can have a detrimental effect on game fisheries.

Invertebrates are found in most aquatic habitats, including small streams that do not support fish. They generally have limited mobility and as such are useful indicators of localised environmental conditions. In addition, they have relatively long lives and are present throughout the year. This means that it is possible to carry out monitoring for long periods of time at a single site. There are a large number of species associated with freshwater habitats, and different stressors, such as organic pollution, acidification and abnormally low flow rates produce different invertebrate communities. By examining the invertebrate fauna at a site an experienced biologist will be able to determine relatively quickly whether the watercourse is impacted or not.

Methods

Data for sites on the main stem of the River Spey was obtained from SEPA. This data covered 19 sites and contained 21,379 individual data points relating to sampling visits between 1981 and 2019. The coverage of the data was investigated in terms of both spatial and temporal coverage (figure 1).



Representative sites were selected for further analysis based upon their location on the river, ensuring that sites were present in the upper, middle and lower river. Only sites with sufficient annual samples were selected. There was however a paucity of modern data for sites on the lower river. To remedy this shortage, the location of sampling sites were checked to see if any were sufficiently close enough to each other to justify combining their sampling data. The sites at Aberlour (NJ 28357 45093) and Arndilly (NJ 29176 46011) are separated by just over a kilometre and whilst the River Fiddich joins within this reach it is considered that the conditions at these two sample points should be sufficiently similar to allow the combination of the data.

The final locations chosen for further analysis are detailed in table 1 and shown in figure 2 and 3.

UPPER RIVER		
Garva	downstream of Garva Bridge	NN 52226 94799
Kingussie	upstream of Kingussie WWTW	NN 75995 99795
MIDDLE RIVER		
Dalfaber	at Dalfaber Lodges	NH 90721 12989
Grantown	downstream Grantown WWTW	NJ 03949 26334
LOWER RIVER		
Aberlour Arndilly	downstream Aberlour WWTW at Arndilly	NJ 28357 45093 NJ 29176 46011
Fochabers	upstream of Fochabers Bridge	NJ 33990 59415

Table 1. locations chosen for further analysis

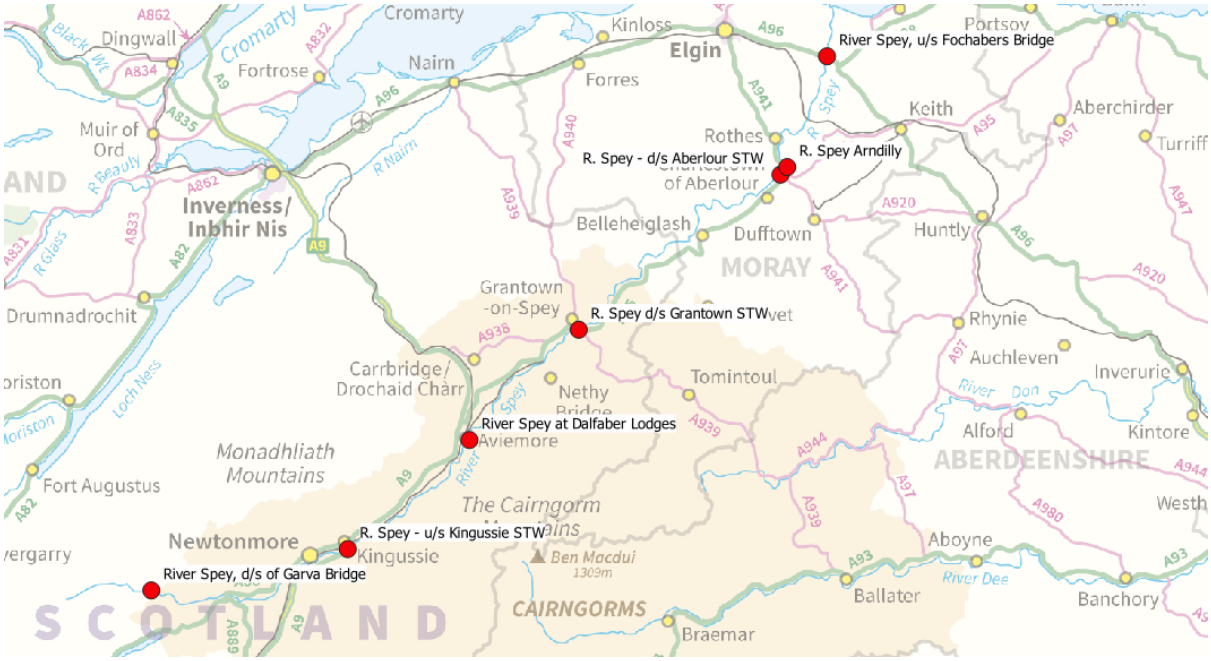


Figure 2. locations chosen for further analysis

a) River Spey downstream of Garva Bridge

b) River Spey at Kingussie

c) River Spey at Dalfaber

d) River Spey at Grantown

e) River Spey at Aberlour

f) River Spey at Fochabers Bridge

Figure 3. Locations used in the data analysis

The data comprises a mix of species and family level information. For some sites (notably Dalfaber and Aberlour/Arndilly) species data was only collected up to around 2000. Where species level data is required for calculation of the metrics this is only possible for the time period where species level data occurs.

Abundance data has been recorded using three different methods: between 1981 and 1989 Chandler abundance categories (table 2) were used. Between 1990 and 2004 abundances were recorded using BMWP categories based on a log scale (table 2). Absolute abundances were recorded from 2004 to the present day.

To allow comparison between these different methods all abundance data was converted to BMWP log abundance categories and assigned an abundance level between 1 and 4 as shown in table 2.

Chandler category	Chandler range	BMWP category	BMWP range	Abundance category
A	1-2			
B	3-10	A	1-9	1
C	11-50	B	10-99	2
D	51-100			
E	101-500	C	100-999	3
F	501-1000			
G	>1000	D	>1000	4

Table 2. Abundance categories

In some years multiple samples have been taken at the same location. The season in which each sample was taken was used to ensure that comparisons are made with data from the same time of year. Most samples were taken in Spring and this was therefore used to calculate most of the results described. In some cases data from the Autumn sampling period was also used to provide a comparison with the Spring data.

Calculation of Biotic Indices

Various indices of environmental quality were calculated from the data as follows.

BMWP the Biological Monitoring Working Party (BMWP) score is a biotic index that is used to ascertain the level of organic enrichment present in a watercourse. Each family is assigned a value between 1 and 10 depending on how sensitive they are to organic pollution. The most tolerant families (eg worms and non-biting midges) are assigned the lowest scores whilst families that are particularly sensitive to organic pollution (eg stoneflies and mayflies) score more highly. The final BMWP score is calculated by summing up the individual scores for each family present.

Ntaxa Number of scoring families used in the calculation of the BMWP score. This can be used as a measure of the richness that of the sample.

ASPT the BMWP score can naturally vary considerably between sites on the same river and between seasons and is influenced by family richness of the sample. To help account for these variations the BMWP score can be divided by the number of scoring taxa (Ntaxa) to give the Average Score Per Taxon (ASPT). Theoretically the results of this calculation can range from 1 to 10, however because low scoring (ie pollution-tolerant) families are also

found in unpolluted watercourses it is incredibly unlikely that a maximum score would be achieved.

Interpretation of BMWP and ASPT

Generally speaking the higher the BMWP score, the less polluted the site is. However, the score should be considered in conjunction with the ASPT, where scores of 6 and above are considered to be 'excellent' and scores below 3 considered to be very poor. Table 3 provides details of a simple interpretation of the BMWP and ASPT scores.

BMWP	ASPT	Description
Over 85	≥6.0	Excellent
70 – 84	≥5.0	Good
50 – 69	≥4.2	Fair
15 – 49	≥3.0	Poor
0 – 15	<3.0	Very poor

Table 3. Interpretation of BMWP and ASPT scores

LIFE the Lotic-invertebrate Index for Flow Evaluation works in a similar fashion to the ASPT score. Individual families are assigned a score depending on their association with different flow types, where those families associated with rapid flows, such as stoneflies and mayflies, are given a higher score than those associated with drought impacted sites (such as water beetles and snails). In contrast to the BMWP score, the LIFE score incorporates a measure of abundance in the calculation. Sites with higher flows (on average) should return higher LIFE scores.

PSI the Proportion of Sediment-sensitive Invertebrates investigates the impacts of sedimentation on the watercourse. It follows a similar method of calculation to that of the LIFE score, however instead of considering the association with flow, the PSI score associates each family with their sensitivity to fine sediment. The final PSI score represents the percentage of fine sediment associated families present in the sample. PSI scores range from 0 (entirely silted river bed) to 100 (entirely silt-free river bed). Table 4 provides a full interpretation of the PSI score.

PSI	River bed condition
81 – 100	Minimally sedimented/unsedimented
61 – 80	Slightly sedimented
41 – 60	Moderately sedimented
21 – 40	Sedimented
0 - 20	Heavily sedimented

Table 4. Interpretation of PSI score

AWIC the Acid Waters Indicator Community score investigates the impact of acidity on the macroinvertebrates of the watercourse. It is calculated in a similar fashion to the BMWP/ASPT score, however instead of considering the sensitivity to organic pollution, the AWIC associates each family with their sensitivity to low pH. Sites with lower AWIC scores have likely been impacted by acidic episodes. Table 5 provides a comparison between the AWIC score and mean pH.

AWIC	Mean pH	Range
2.0	5.46	4.55 – 6.37
2.5	5.84	4.93 – 6.75
3.0	6.22	5.31 – 7.12
3.5	6.60	5.69 – 7.50
4.0	6.98	6.07 – 7.88
4.5	7.36	6.45 – 8.27
5.0	7.74	6.83 – 8.65
5.5	8.12	7.21 – 9.03
6.0	8.50	7.59 – 9.41

Table 5. Interpretation of AWIC score

WHPT the Walley, Hawkes, Paisley & Trigg method is an improved version of the BMWP score, which indicates the overall ecological quality of watercourses, rather than just the impact of organic pollution. Individual scores for each family are assigned according to their sensitivity to organic pollution and other major pressures and are also dependent on the abundance of the family in the sample. The WHPT index is calculated by summing the individual scores and dividing by the number of scoring families to derive an average score per taxon.

These indices all utilise family level data. Where only species level data was available these data were aggregated into families to allow calculation of the indices.

Measures of Diversity

The biotic indices described above are calculated using family level data. To look at what is happening at the species level it is necessary to use diversity indices.

Diversity indices are useful to compare species diversity between samples and sites. The **Shannon Diversity index** explores both species richness and species evenness in samples. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase.

Simpson's Diversity index further explores the evenness of the sample by investigating the dominance of individual species within the sample. It is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. The result of the calculation of Simpson's Diversity index is subtracted from one to give a score between zero and one. As the value of Simpson's index decreases, diversity (in the sense of evenness) increases. Therefore, in a sample dominated by one or two species the value will be low, whereas in a sample with a fairly even abundance of different species the value will approach one.

Family/Species trends

One of the main reasons for this study is to explore whether there have been changes to the macroinvertebrate populations of the Spey. To investigate trends in macroinvertebrate populations the overall number of riverfly species (mayflies, stoneflies and caddisflies) was calculated. This simple measure gives an indication of the health of the populations of riverfly species in the river.

A selection of families and species of interest to anglers were investigated further.

Mayflies (Ephemeroptera)

Baetidae  © Cyril Bennett	The 'Olives'. This family includes the Large dark olive (*Baetis rhodani*/*atlanticus*) which is an important early season fly on the river. The Baetidae feed on algae on the surface of stones, vegetation and other structures on the bed in of the river. They can therefore be used to investigate eutrophication in the river.
Heptageniidae  © Cyril Bennett	This family comprises a number of important flies including the March brown (*Rhithrogena germanica*), Olive upright (*R. semicolorata*), Yellow May dun (*Heptagenia sulphurea*) and Large brook dun (*Ecdyonurus torrentis*).
***Rhithrogena* sp.**  © Cyril Bennett	This genus includes the March brown and Olive upright. These two species can't be separated as nymphs so SEPA record them as the genus *Rhithrogena*.

Stoneflies (Plecoptera)

Perlidae  © Paul Kennedy	This family comprises two species (*Perla bipunctata* and *Dinocras cephalotes*). Both of these species take over three years to develop which makes them a good indicator of conditions in the river. They also have large nymphs which form an important part of the diet of trout and juvenile salmon.
Leuctridae  © Paul Kennedy	The 'needle-flies'. This family comprises six species of stonefly which emerge throughout the year.
Isoperla grammatica  © Paul Kennedy	The Yellow Sally. This species can be an important fly in the early summer.

Caddisflies (Trichoptera)

Hydropsychidae  © Sharon Flint	The 'grey flags'. This family comprises five species that can be important late season flies on the river. They feed by filtering food from the water column and can therefore be used to investigate the amount of suspended solids in the water column.
Rhyacophilidae  © Janet Graham	The 'sand fly sedges'. These free-living caddis are predators which emerge through the summer months.

Brachycentridae  © Hallvard Elven	The 'Grannom'. This family represents a single species *Brachycentrus subnubilus* which is an important early season fly on the river. The larvae feed by collecting small particles from the water column. They are often associated with beds of aquatic weeds (such as *Ranunculus*) and they can be very abundant where there are extensive growths.
Glossosomatidae  © Casper Zuyderduyn	The 'micro grey sedges'. These tiny caddis create a small humped case which is attached to a stone on the river bed. They can be an important fly in the summer and their larvae can stabilise significant quantities of fine sediment.
Lepidostomatidae  © Janet Graham	The 'small silver sedge'. This family represents a single species in the Spey, *Lepidostoma hirtum*. This species can be an important fly in the late summer.
Sericostomatidae  © Sharon Flint	The 'Welshman's button'. This family represents a single species in the Spey, *Sericostoma personatum*. This species can be an important fly in the summer.

Other species

Two other families were investigated as important indicators for conditions in the river.

Chironomidae  © Entomart	The non-biting midges, known as 'buzzers' by anglers. The Chironomidae are tolerant for of a wide range of water quality conditions. In the most polluted conditions you may only find non-biting midges and worms, however they can also be found in good quality watercourses, albeit in lower numbers. It is therefore possible to look at where high abundances of Chironomidae are recorded to investigate whether conditions in the river are changing.

Simuliidae  © Robert Webster	The blackflies. The larvae of these tiny insects attach themselves to the surface of rocks and stones in fast flowing. They have fan-like moth parts which they use to filter tiny particles from the water column. They can occur in large numbers and can be an important prey item for juvenile salmon.

Results

The following pages provide graphs showing the relative abundance of the families and species of invertebrates described above. Figures 2 and 3 show the overall trend in Chandler abundance for two periods: 1981 to 1999; and 2000 to 2019. In these figures red cells signify decreasing trends, green cells signify stable or increasing trends, and white cells show where a family was not recorded in that period. It should be noted that no measure of statistical significance has been calculated for these trends.

	1981 to 1999						2000 to 2019					
	Garva	**Kingussie**	**Dalfaber**	**Grantown**	**Aberlour/ Arndilly**	**Fochabers**	**Garva**	**Kingussie**	**Dalfaber**	**Grantown**	**Aberlour/ Arndilly**	**Fochabers**
Baetidae												
Brachycentridae	Abs						Abs					
Chironomidae												
Glossosomatidae	Abs						Abs					
Heptageniidae												
Hydropsychidae												
Lepidostomatidae												
Leuctridae												
Perlidae												
Rhyacophilidae												
Sericostomatidae	Abs											
Simuliidae												
Baetis rhodani									N/D		N/D	
***Rhithrogena* spp.**									N/D		N/D	
Isoperla grammatica									N/D		N/D	

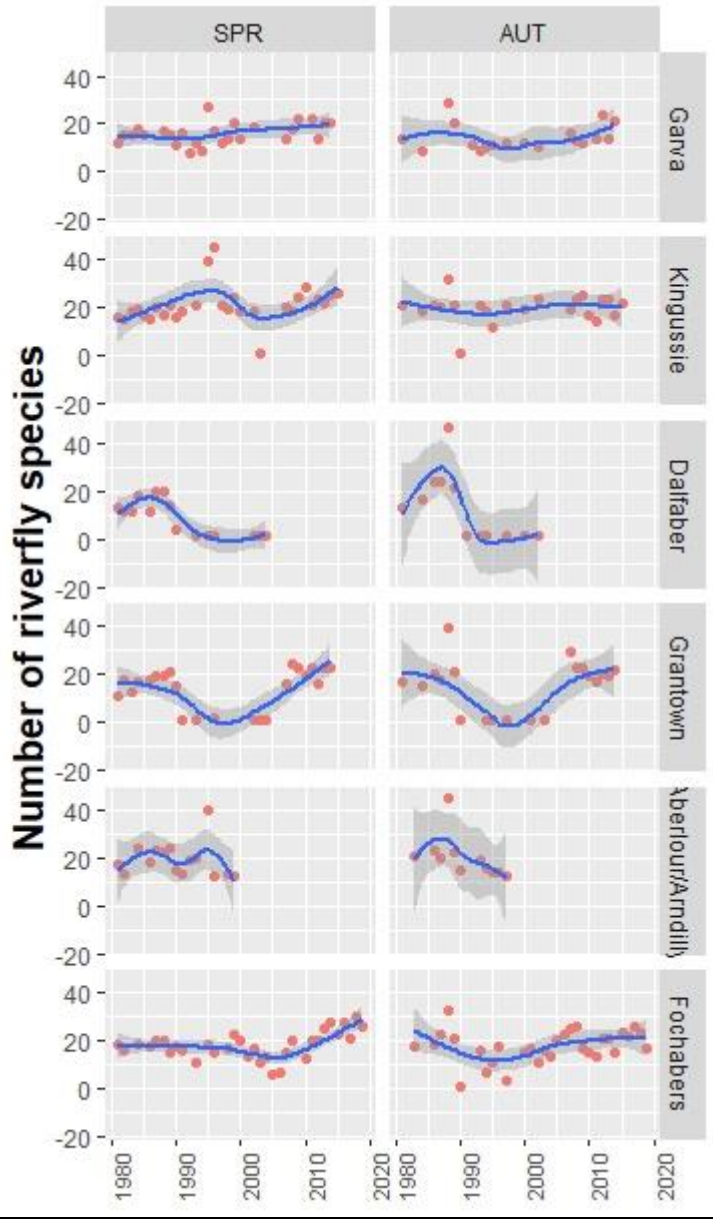
Figure 2: Trends in BMWP abundance in 1981 to 1999 (pre) and 2000 to 2019 (post). Abs = Absent; N/D = no data

Trends for individual families are presented on the following pages as graphs showing the individual data points in red for spring (SPR) and autumn (AUT) samples. Superimposed on these charts is a blue line representing the smoothed conditional mean of the data calculated using local polynomial regression fitting (loess). This method allows us to observe any trends in the data. The dark grey area around the blue line is the confidence interval for the smoothed trend. The larger the distance between the line and the edge of this area, the less confident that we can be in the trend.

Overall number of riverfly species

Riverflies include the mayflies, stoneflies and caddisflies which are important food items for trout and juvenile salmon.

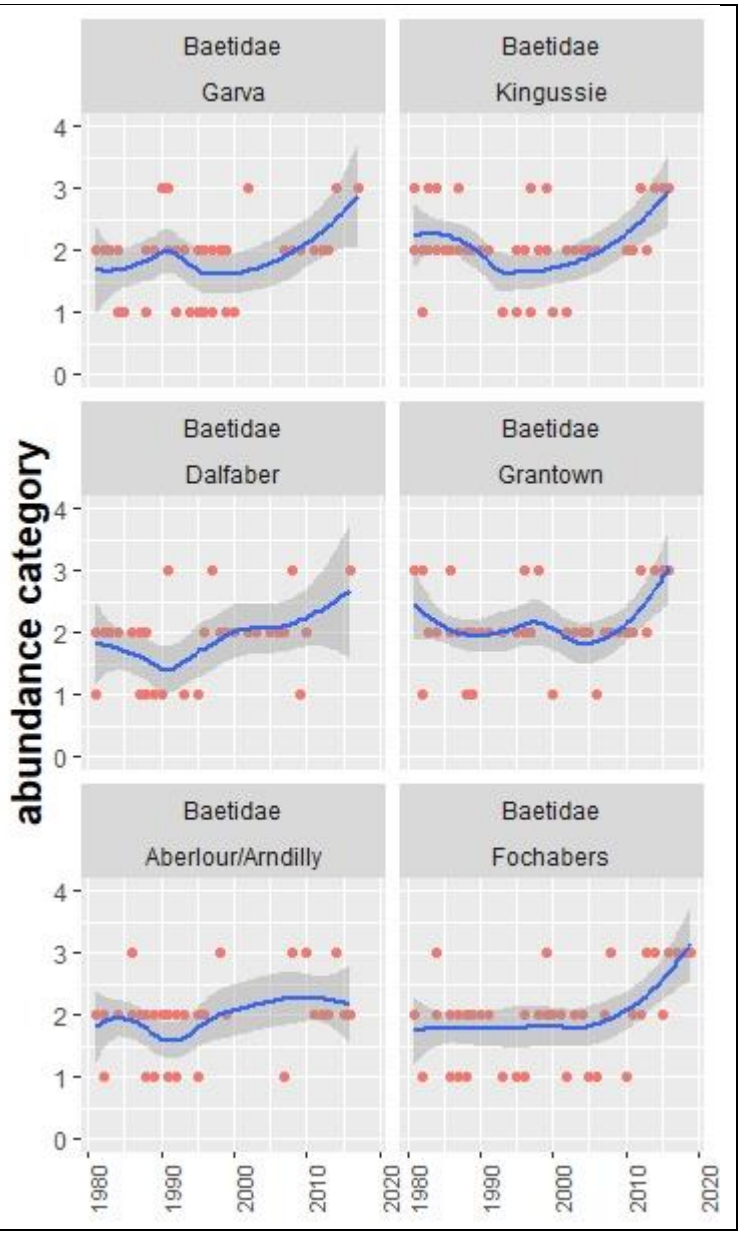
Numbers of riverfly species in the upper river have remained pretty constant over the last 39 years. In the middle river there appears to have been a decrease in the number of riverfly species during the 1990s however the numbers increase to pre-1990 levels during the following 20 years. There is an indication of a similar decline and subsequent recovery of numbers in the lower river however the decline is less severe than in the middle river.



Baetidae

Baetidae appear to be doing well in the Spey, despite a decline in abundance during the 1990s. There are now increases in abundance at all sites on the river.

The Baetidae are more tolerant of organic pollution and warmer waters than the other mayfly families, and if this family alone was increasing it would warrant further investigation, however the increase in abundance of the Heptageniidae would suggest that the increase in the Baetidae is part of a more general recovery and increase in abundance of mayfly families as a whole.

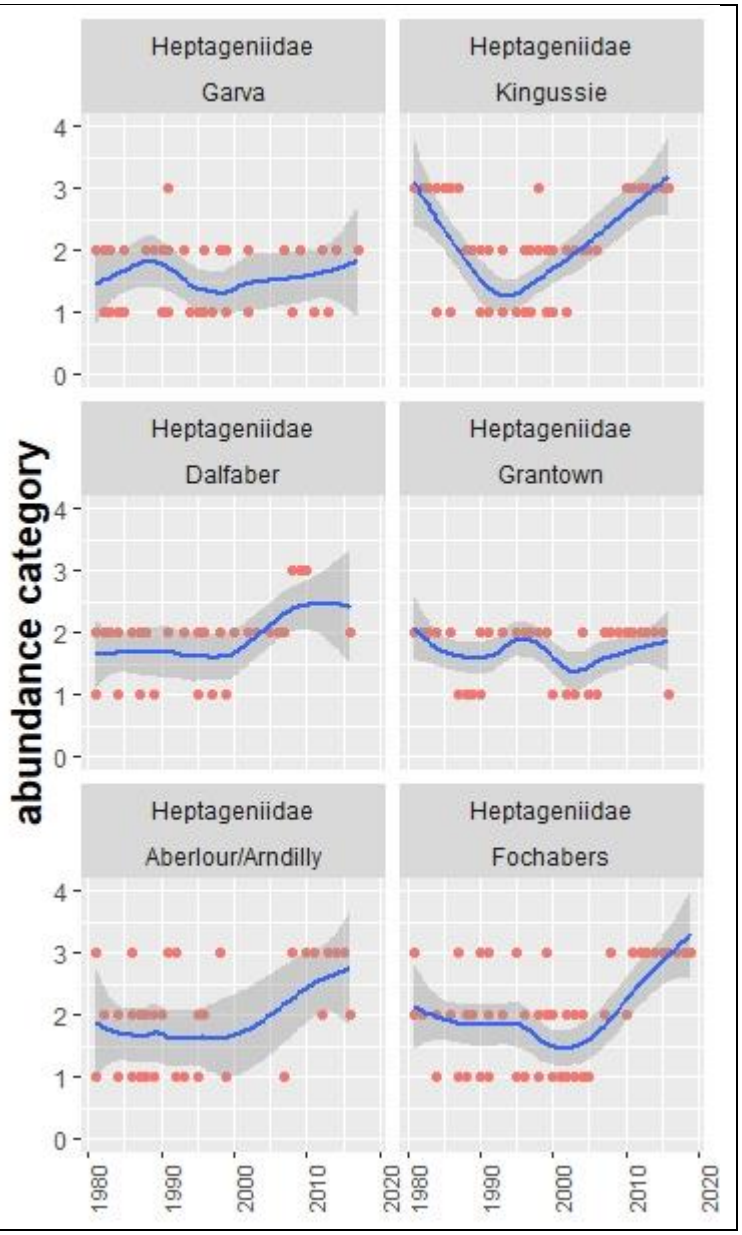


Heptageniidae

The abundance of Heptageniidae in the river at Garva has remained relatively constant across the 39 years. At Kingussie there appears to have been a sharp decline in numbers during the 1990s however the population has now recovered to the levels found in the 1980s.

The middle rivers show some variation in numbers but overall the abundance has remained fairly steady throughout the period.

In the lower river there appears to have been an increase in numbers of Heptageniidae. In the later years this trend is mainly due to increases in the number of *Ecdyonurus* and *Rhithrogena* nymphs.



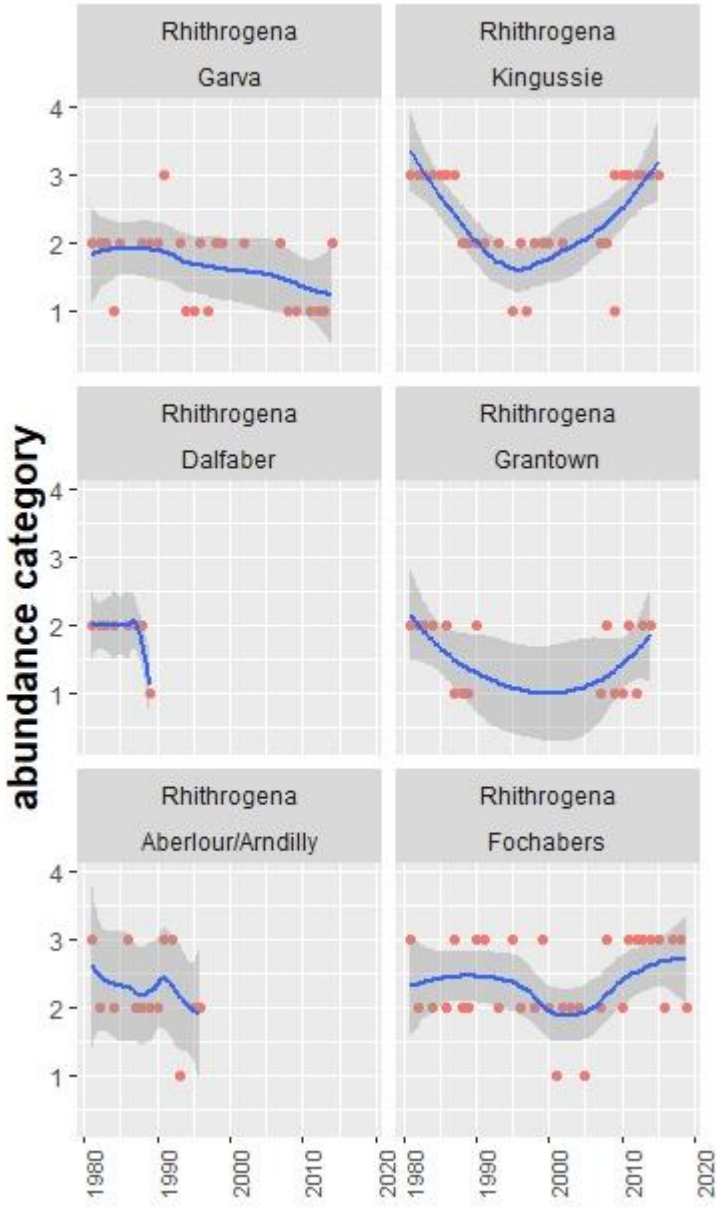
Rhithrogena spp.

Due to a change in identification precision there is insufficient data to compare trends for Dalfaber and Aberlour/Arndilly. At all other sites the abundance of *Rhithrogena* is at, or above the levels present in the 1980s. At Garva the numbers have remained relatively stable over the whole monitoring period. They are generally lower than at other sites however that is probably due to the conditions in the upper river being less suitable for both *Rhithrogena* species, but particularly the March brown (*Rhithrogena germanica*), which favours larger, deeper reaches.

The results at Kingussie show a decline in numbers through the 1990s and subsequent recovery.

At Grantown, samples were only identified to family during the 1990s/2000s which means that we can't separate the data for the two *Rhithrogena* species from the other Heptageniidae present in the river. Therefore, our confidence in the trend depicted is low, however the current abundance levels match those in the 1980s.

Finally, at Fochabers the population of *Rhithrogena* spp. appears stable although there may have been a slight decline during the early 2000s, however the abundance now is similar to that in the earlier years.

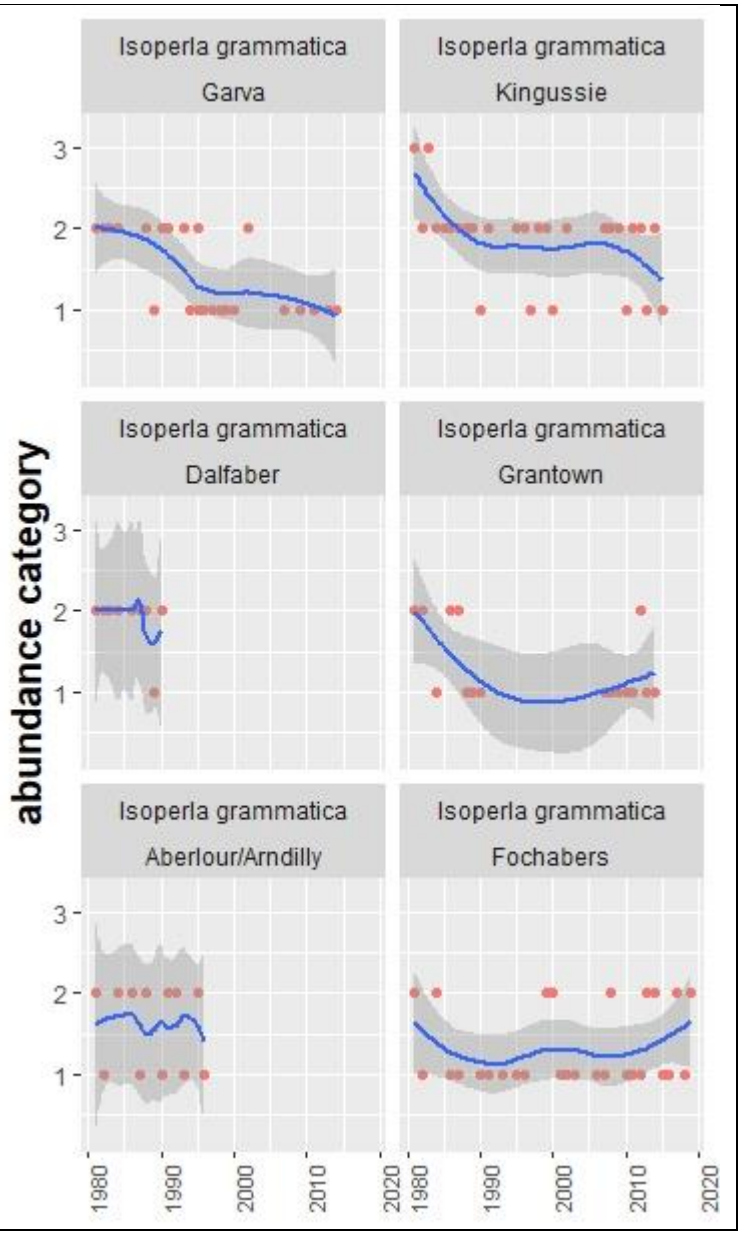


Isoperla grammatica

Due to a change in identification precision there is insufficient data to compare trends for Dalfaber and Aberlour/Arndilly. It should however be noted that Perlodidae, the family that *Isoperla grammatica* belongs to, has been recorded at these sites in subsequent years.

At the other sites there appears to have been a slight decline in numbers of this species in the upper and middle river.

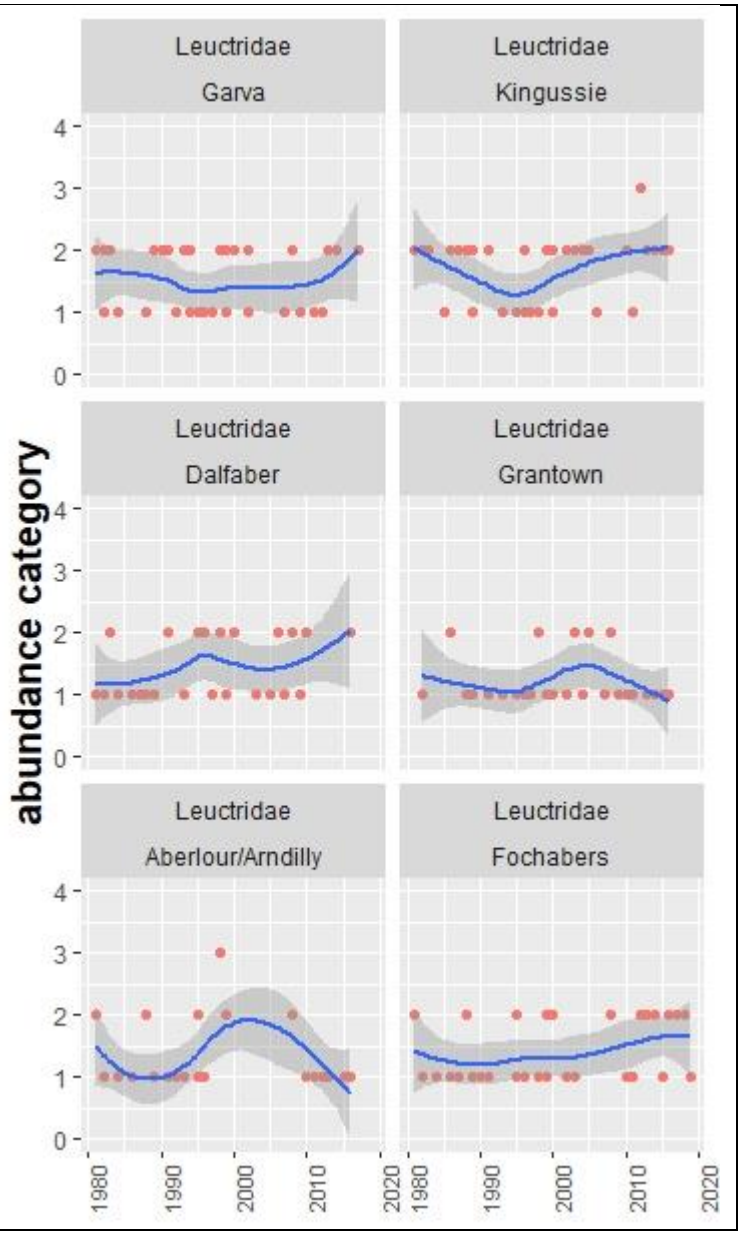
In the lower river, the site at Fochabers shows a decline in the 1980s and 1990s with a recovery in recent years.



Leuctridae

The abundance of needle-flies has remained relatively stable over the 39-year period. At Kingussie there is evidence of a dip in abundance during the 1990s, with a recovery to previous levels in recent years.

The exception to this is at Aberlour/Arndilly where the trend appears to be declining at the present. However, looking at the individual data points there is considerable variation from year to year and it is likely that this is influencing the profile of the trend line. It is also worth noting that there are not many data points in the higher abundance categories, with most years recording between 1-9 individuals.



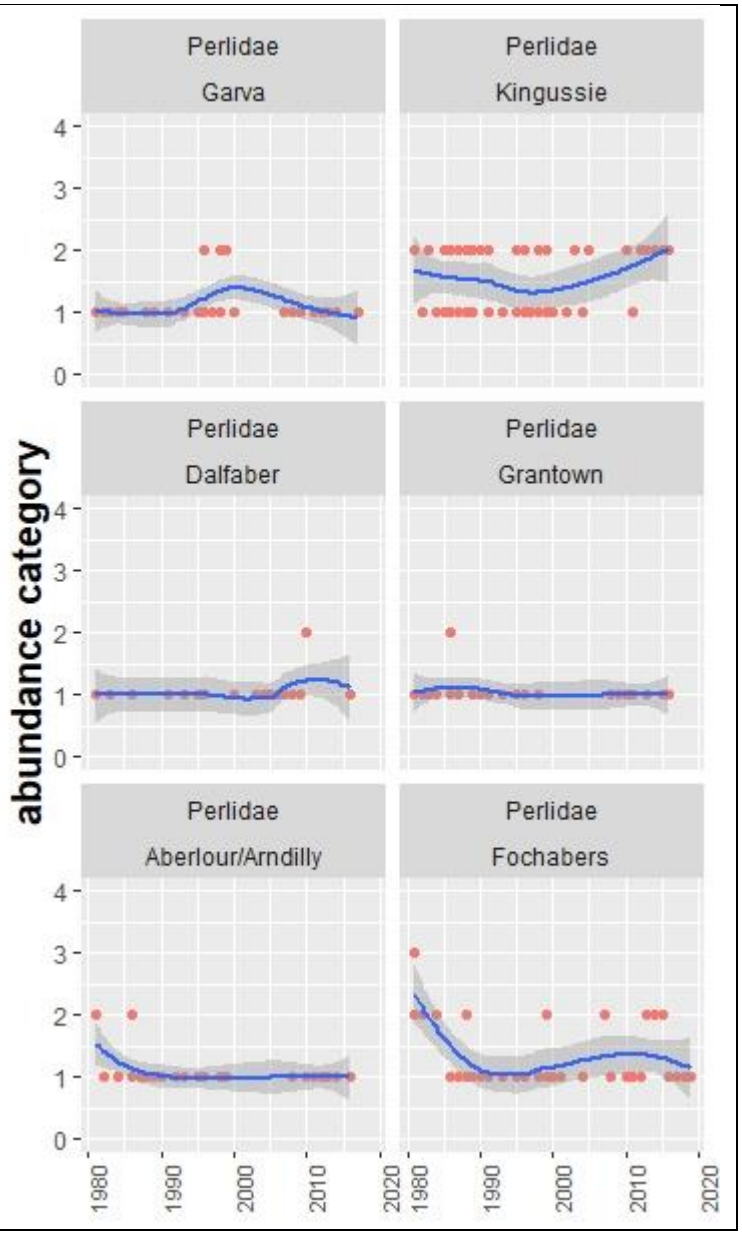
Perlidae

The trends for the Perlidae broadly follow the trends for other families, with a decline in abundance during the 1990s followed by a recovery in the 2000s and 2010s.

The long life cycle of the Perlidae (up to 3.5 years in *Perla bipunctata*) will mean that any recovery of the population will take longer, and this appears to be the case in the lower river, where the numbers generally remain lower until the most recent years.

In the middle river this family is rarely present in double figures and most recent results are in abundance category 1 (1-9 individuals). As a result no obvious trend is apparent in the data.

In the upper river the population appears stable with good numbers at Kingussie in particular, where they are often recorded in abundance category 2 (10-99 individuals).

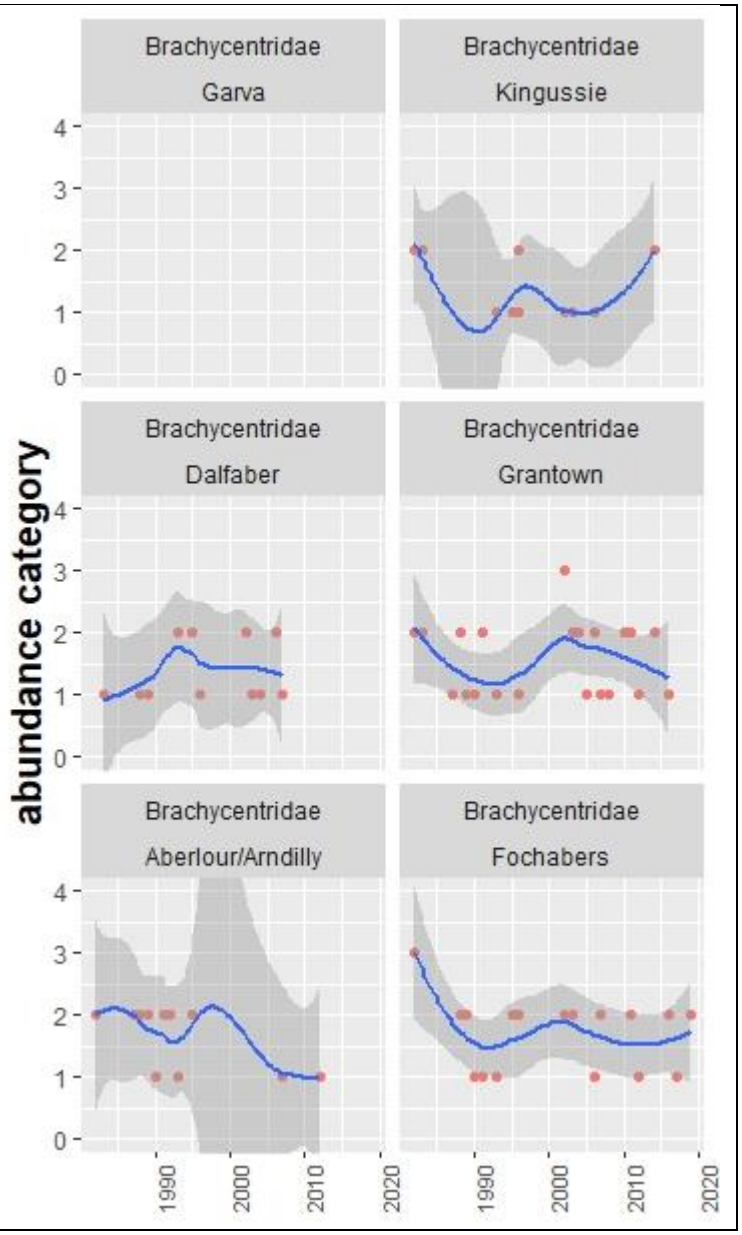


Brachycentridae

The Brachycentridae can have quite large natural variations in their population size.

This family is absent at Garva, and at Kingussie, the population shows some years with large peaks in abundance. In the middle river there are no spring records of Brachycentridae at Dalfaber after 2007 although 240 Brachycentridae larvae were recorded in the autumn sample in 2016. At Grantown the trend shows a decline in the 1990s followed by recovery.

In the lower river there are several years where sampling has not detected Brachycentridae at Aberlour/Arndilly. This means that our confidence in the trend is lower, however it may also indicate a problem with the population of this caddisfly in this area. At Fochabers the abundance has remained relatively stable across the study period.

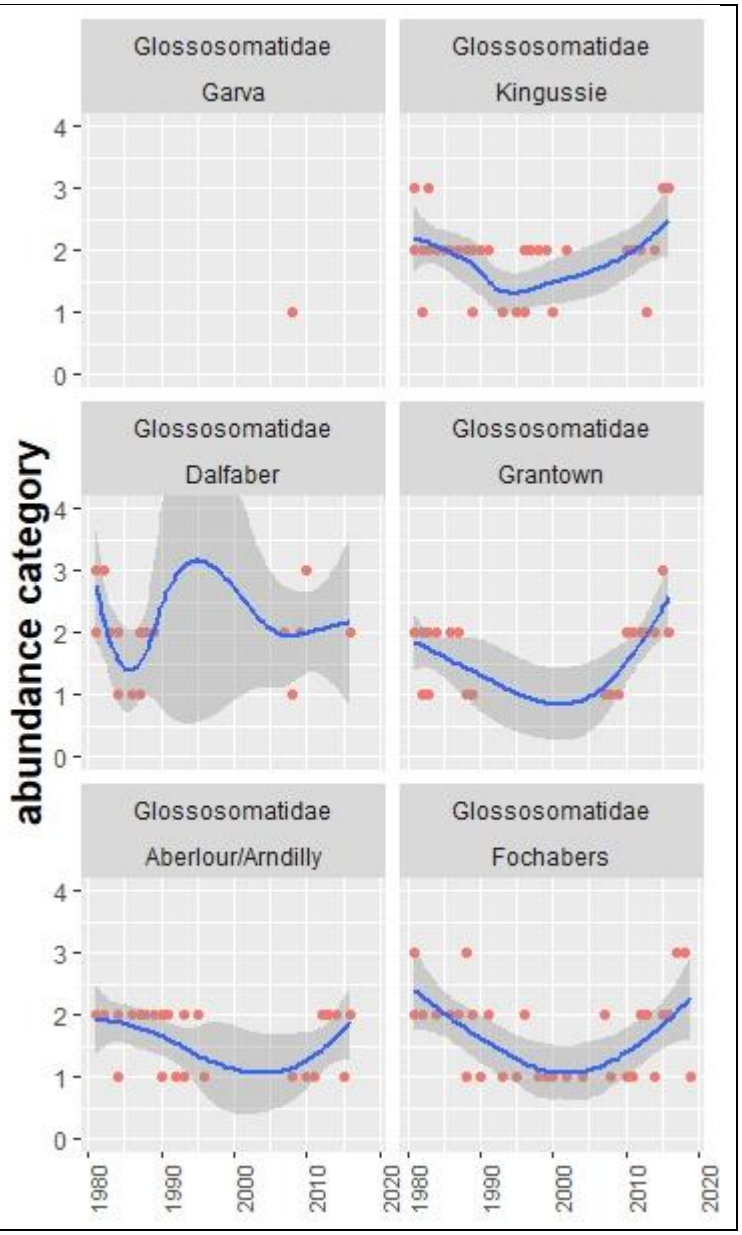


Glossosomatidae

This caddisfly species has only been recorded once at Garva. At Kingussie the abundance is good, although there is evidence of a decline during the 1990s.

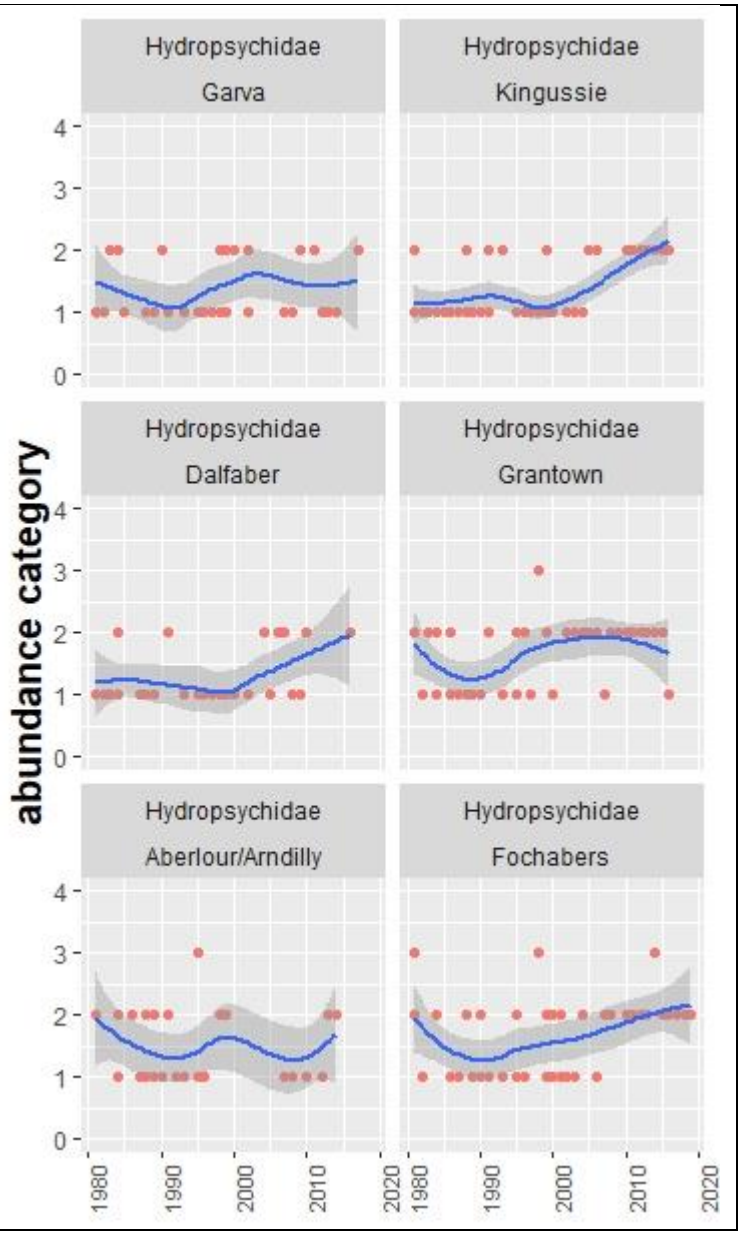
In the middle river, this species was apparently absent from the river in the 1990s and early 2000s. The population has however recovered since to pre-1990 levels of abundance.

Similarly, in the lower river there are no records of Glossosomatidae at Aberlour/Arndilly between 1996 and 2008, however subsequent years have good abundance levels of this caddisfly, although not at the levels seen at other sites on the river. At Fochabers the abundance dips during the late 1990s and then recovers to pre-1990 levels during the 2000s and 2010s.



Hydropsychidae

The abundance of this caseless caddisfly is relatively stable at all sites on the river. In the lower river there can be high numbers of this family with 100 to 999 individuals recorded on several occasions. More typically the abundance is the range 10 to 99.

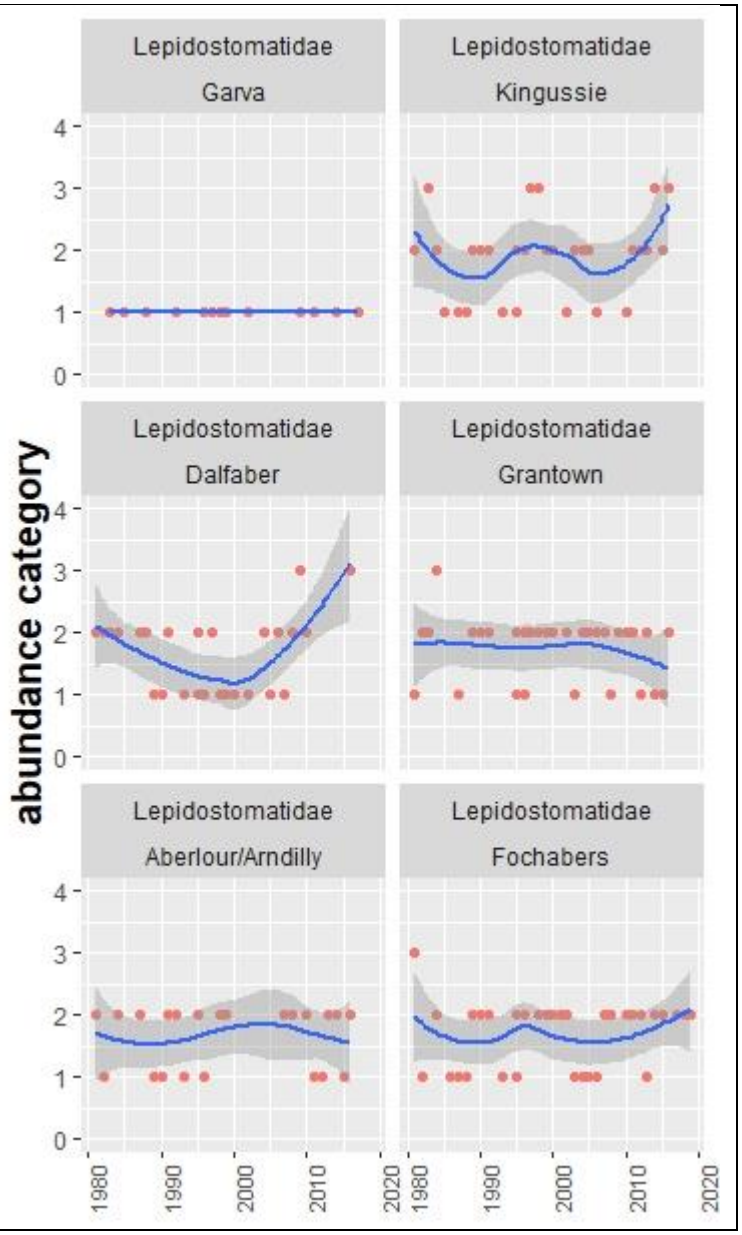


Lepidostomatidae

In the upper river this caddisfly family is relatively uncommon at Garva, however regularly turns up in low numbers in samples. At Kingussie there are regularly greater numbers of this family.

At Dalfaber there appears to have been a decline in abundance during the 1990s before the population increased substantially, culminating in 608 individuals being recorded in 2016. At Grantown the population is regularly in abundance category 2 (10 to 99 individuals).

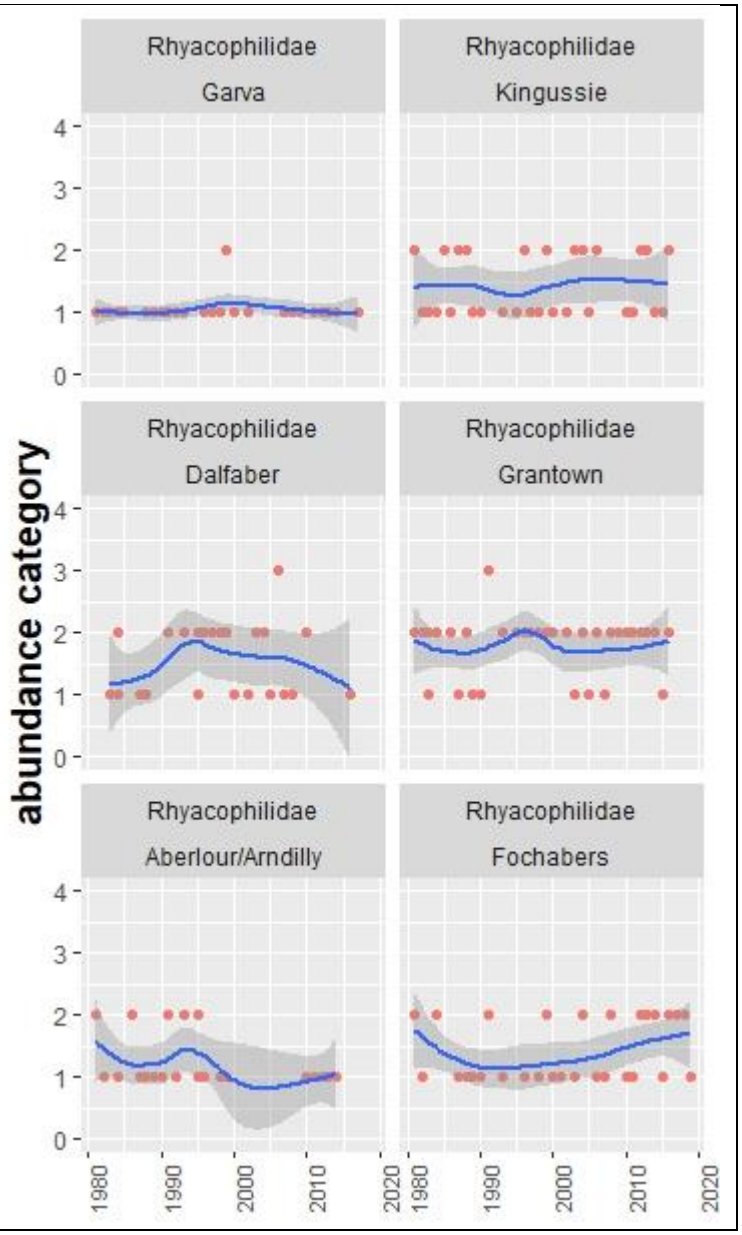
In the lower river the population also appears to be stable with abundance in category 2 (10 to 99 individuals).



Rhyacophilidae

This caddisfly is uncommon at Garva with only 1-9 individuals recorded in most years. The abundance of this caddisfly family at all other sites on the river appears stable with most sites recording between 10 to 99 individuals per sample visit. There are occasionally higher abundances, notably in the middle river with both Dalfaber and Grantown recording over 100 individuals in a sample on one occasion.

At Aberlour/Arndilly there appears to have been a slight decline in numbers of this family in recent years.



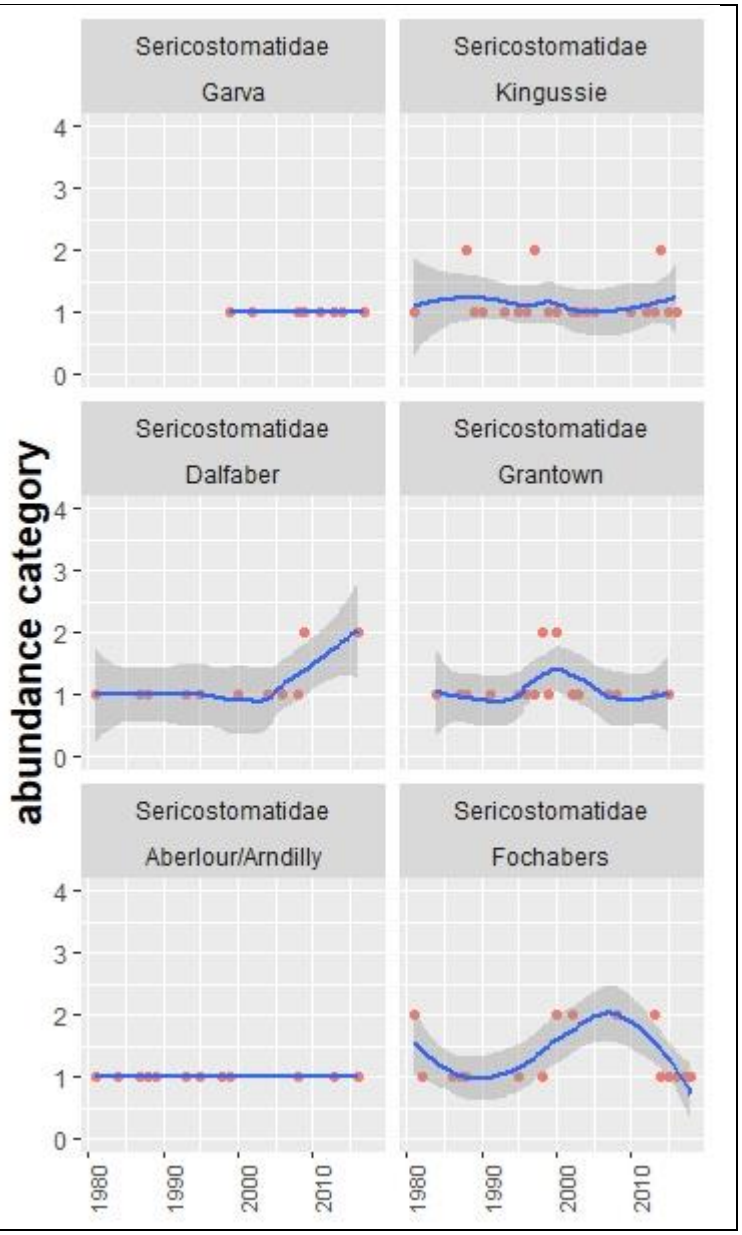
Sericostomatidae

For most sites there are no obvious trends in abundance for this caddisfly family.

At Dalfaber there is a suggestion that the abundance has increased during the 2000s/2010s.

Of interest though is the appearance of Sericostomatidae in the samples from Garva from 1999 onwards. Prior to this there are no records of this family from this site, and whilst there are still only small numbers of this family present it is notable that they appear to have colonised this site.

It is thought that *Sericostoma personatum* (the sole species from this family found in the Spey) favours warmer waters, which may suggest that the water temperature at Garva has increased in recent year.

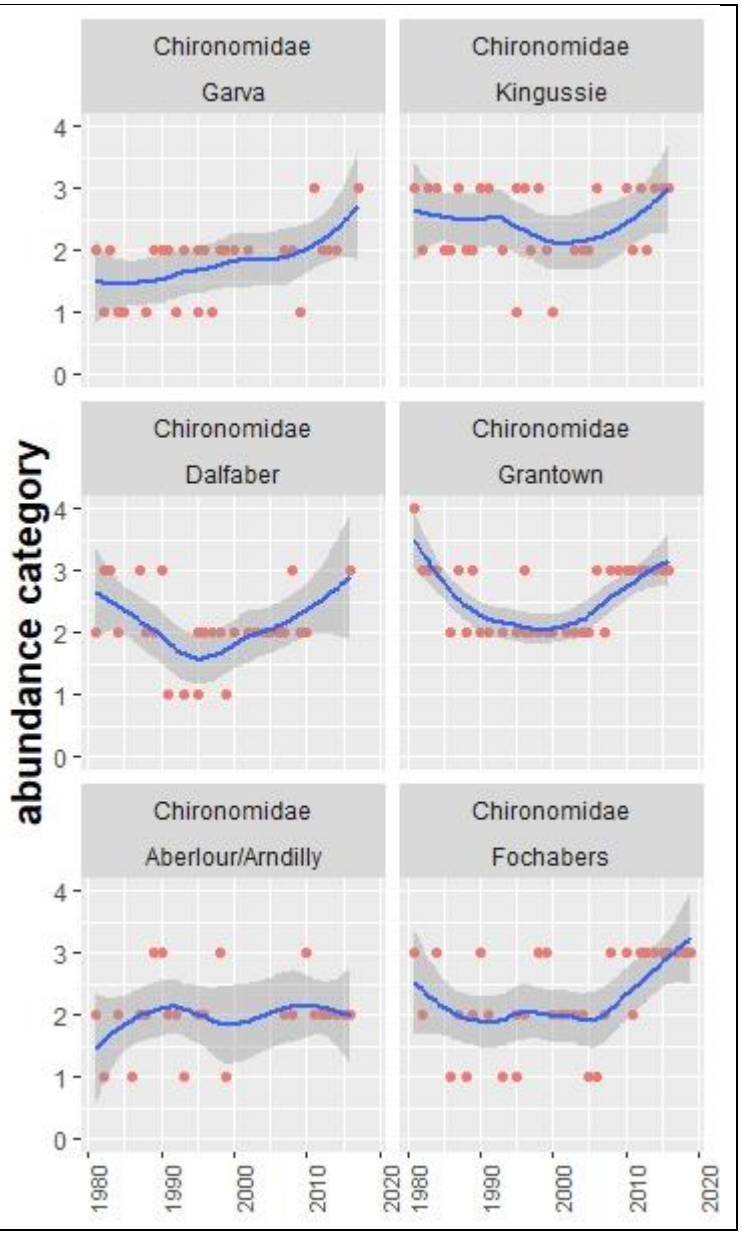


Chironomidae

In the upper river there has been a slight increase in the abundance of non-biting midges at Garva, whereas at Kingussie the numbers remain in the mid to high hundreds through much of the time period. At Fochabers the numbers have steadily increased during the 2000s and 2010s.

In the middle river the number of Chironomidae declined during the 1990s but have now returned to pre-1990 abundances.

The Chironomidae are tolerant of organic pollution, however they are also found in clean, unpolluted waters. The increase in numbers at some sites is worth further investigation to understand the causes of this increase.

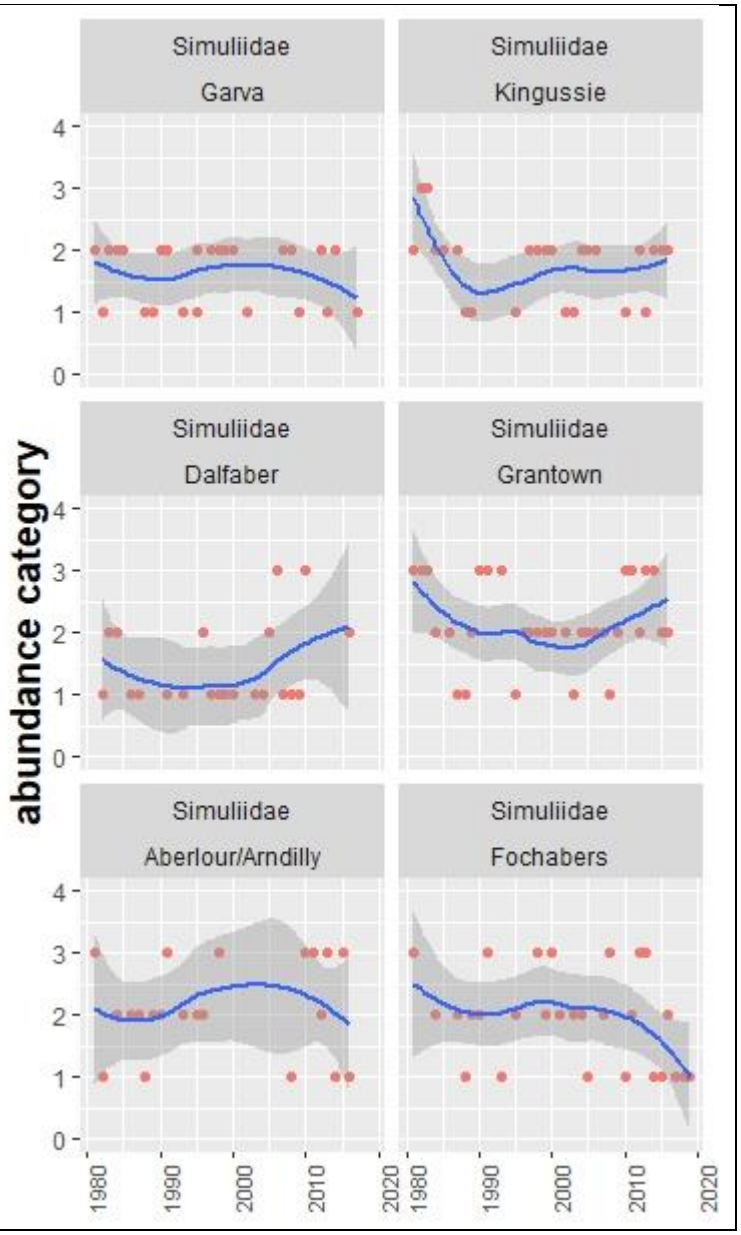


Simuliidae

In the upper river the numbers of Simuliidae larvae have remained relatively stable over the majority of the study period. At Kingussie there were two sampling events which were in abundance category 3 (100 to 999), however for all other sampling visits the numbers were in abundance category 2 or below. As a result, there is an apparent decline during the 1980s however in the remaining years the abundance has remained relatively stable.

In the middle river abundance of Simuliidae appears to have declined during the late 1990s and early 2000s, before recovering in the 2010s. However, at Dalfaber our confidence in these trends is lower.

Similarly, our confidence in the trends at Aberlour/Arndilly is low and as a result no conclusions can be drawn from data. At Fochabers there appears to have been a decline in abundance in recent years



Biotic Indices

The following pages provide the results of the various biotic indices described in the methods section. Figures 4 and 5 show the overall trends in these indices for both spring and autumn samples. In these figures red cells signify decreasing trends and green cells signify stable or increasing trends. It should be noted that no measure of statistical significance has been calculated for these trends, and in many cases the magnitude of change is very small.

Figure 4: Trends in biotic indices for Spring samples.

Index	Garva	Kingussie	Dalfaber	Grantown	Aberlour/ Arndilly	Fochabers
BMWP						
NTAXA						
ASPT						
LIFE						
PSI						
AWIC						
WHPT						
Richness						
Shannon						
Simpson						

Figure 5: Trends in biotic indices for Autumn samples.

Index	Garva	Kingussie	Dalfaber	Grantown	Aberlour/ Arndilly	Fochabers
BMWP						
NTAXA						
ASPT						
LIFE						
PSI						
AWIC						
WHPT						
Richness						
Shannon						
Simpson						

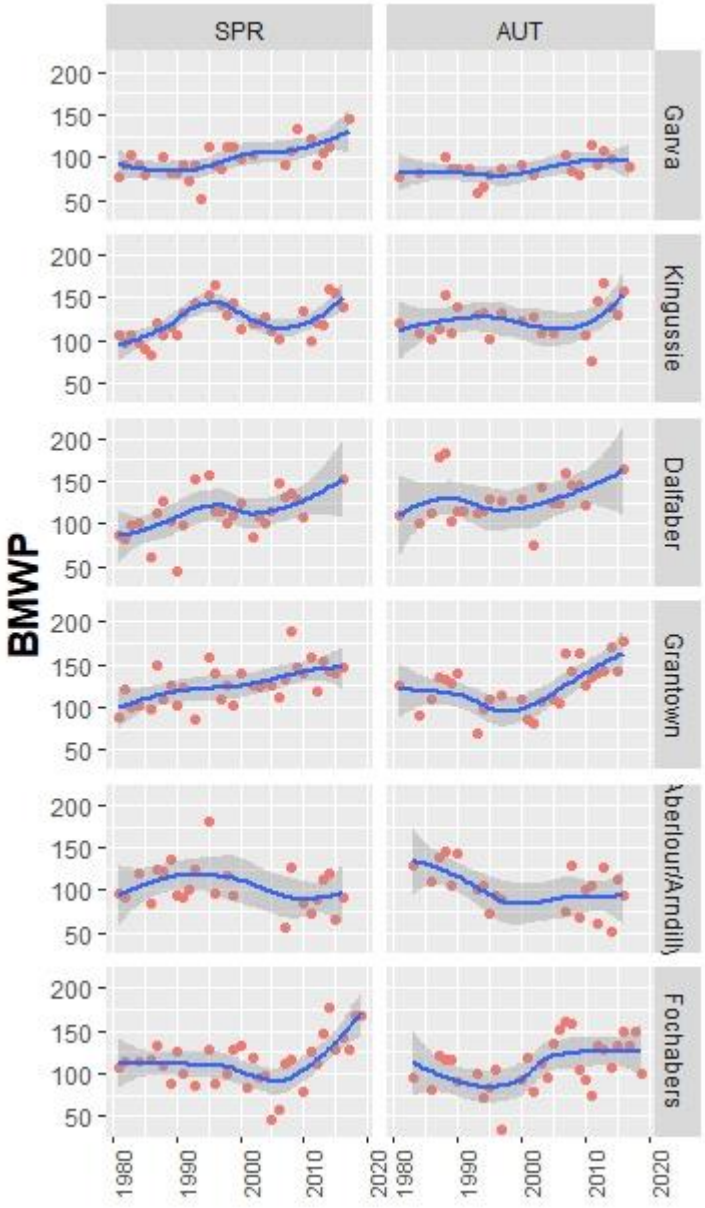
Trends for individual indices are presented on the following pages as graphs showing the individual data points in red. Superimposed on these charts is a blue line representing the smoothed conditional mean of the data calculated using local polynomial regression fitting (loess). This method allows us to observe any trends in the data. The dark grey area around the blue line is the confidence interval for the smoothed trend. The larger the distance between the line and the edge of this area, the less confident that we can be in the trend.

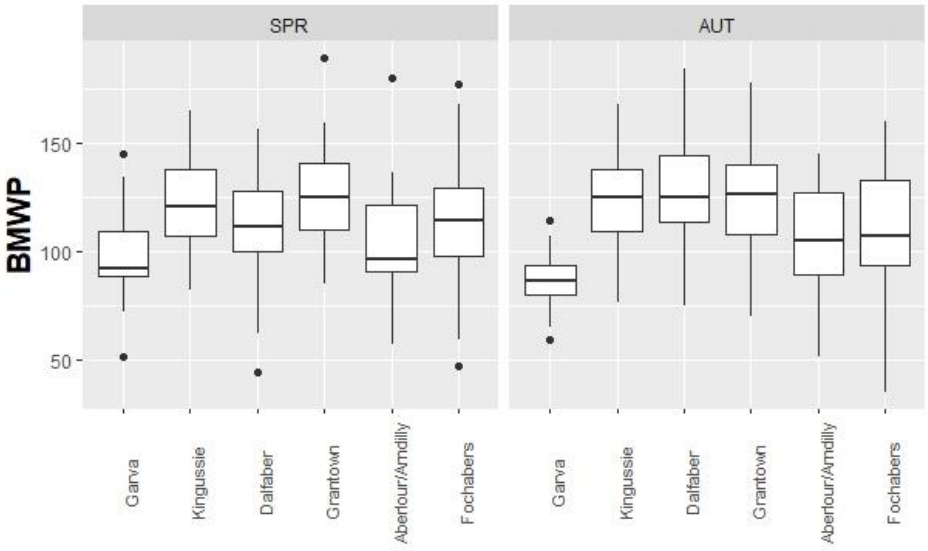
Below these trend graphs, where relevant, there is a separate box plot which shows the range of scores for the indices. The main range of scores is indicated by the box. The solid line indicates the median value and the long vertical lines indicate the minimum and maximum values. Individual dots outwith these lines are outliers, ie isolated high or low scores.

BMWP

At most sites on the river the BMWP score has increased slightly in both the Spring and Autumn across the study period. The exception to this is at Aberlour/Arndilly where the BMWP score appears to have declined slightly in later years. There are however some missing years in the early 2000s which means that our confidence of the overall trend is lower.

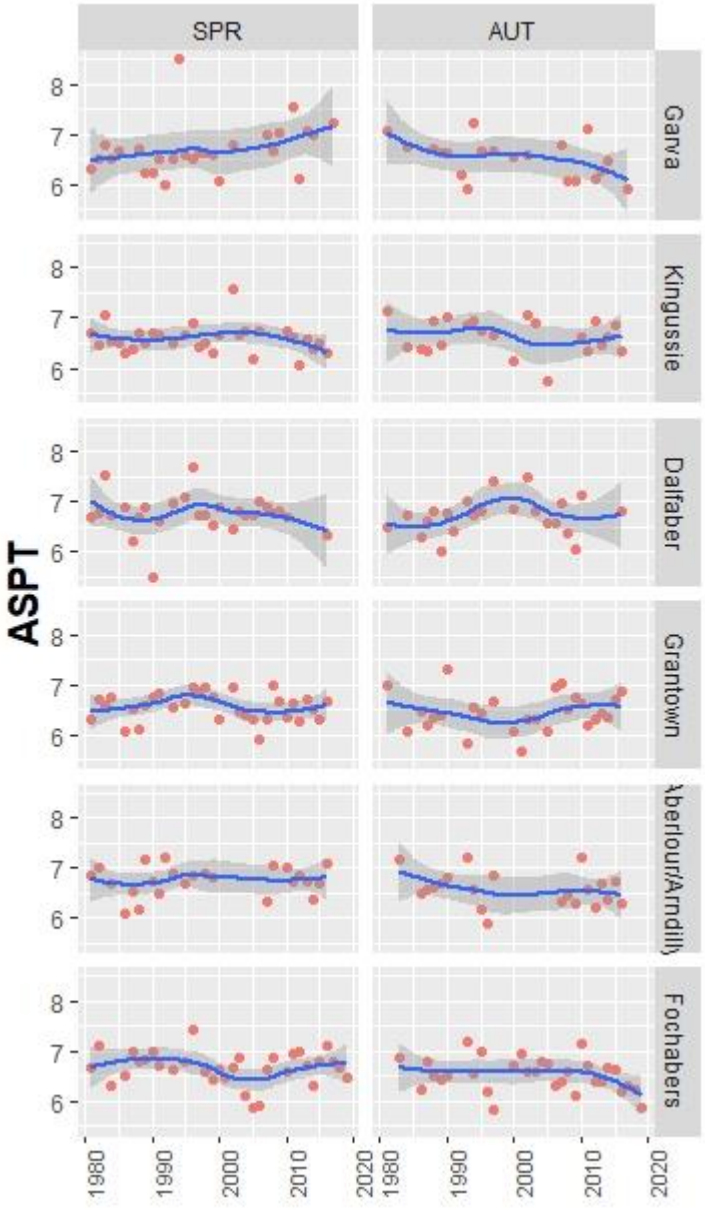
Overall, the majority of results fall in to the 'Excellent' category, with the remainder being 'Good'. There are a couple of lower scores over the 39 year period, however these are isolated occurrences and not part of the overall trend.

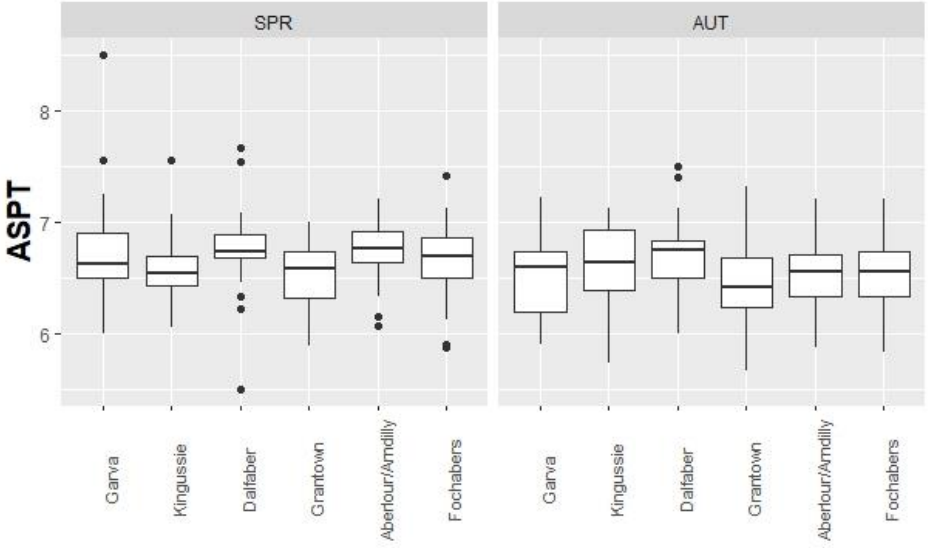




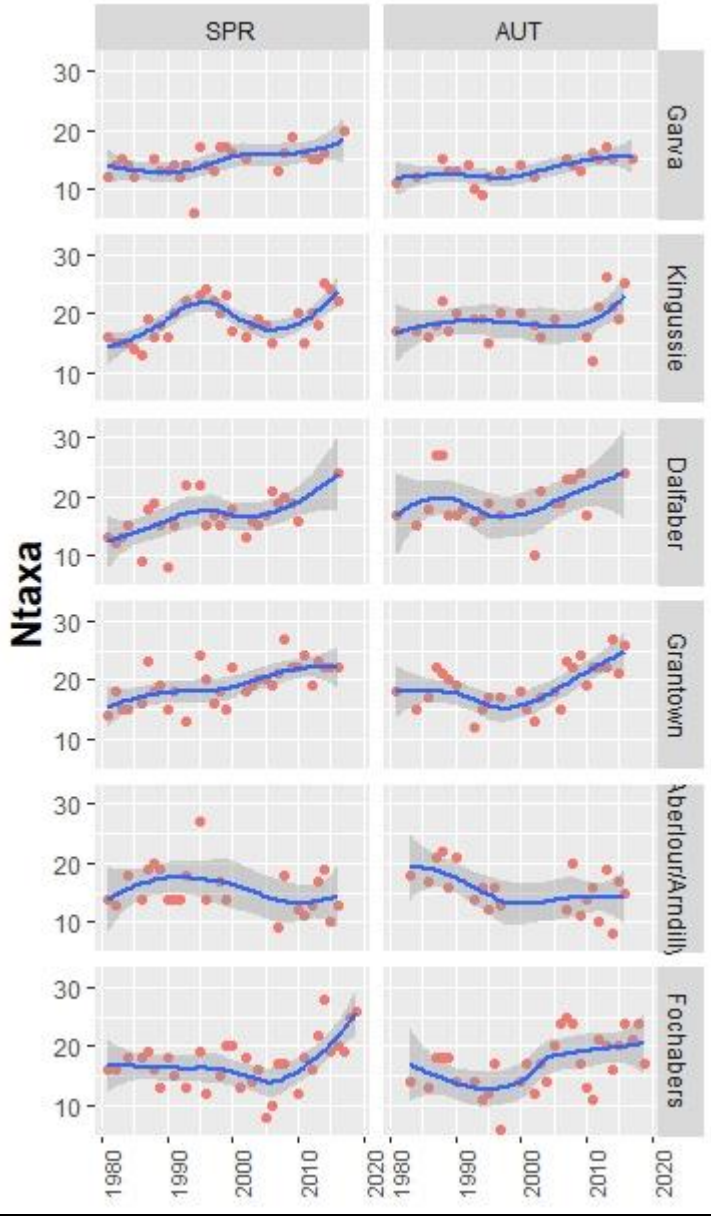
ASPT

The Average Score Per Taxon based on the BMWP score generally shows a fairly even trend. There is some evidence of a slight dip in the ASPT at Kingussie and Dalfaber in the spring samples and Garva and Fochabers in the autumn samples, however it should be noted that despite this there are only 11 samples across the whole 39 year study period that scored below 6.00, indicating that water quality, at least in terms of organic pollution, is very good in the Spey.





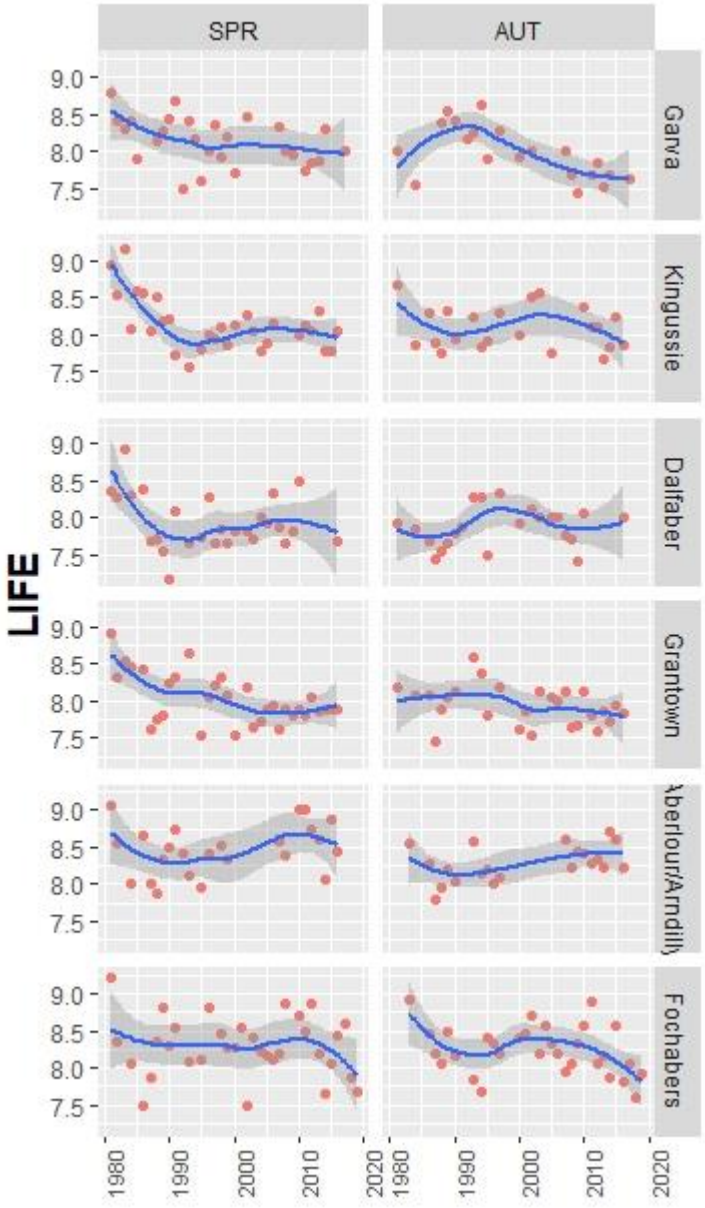
NTAXA

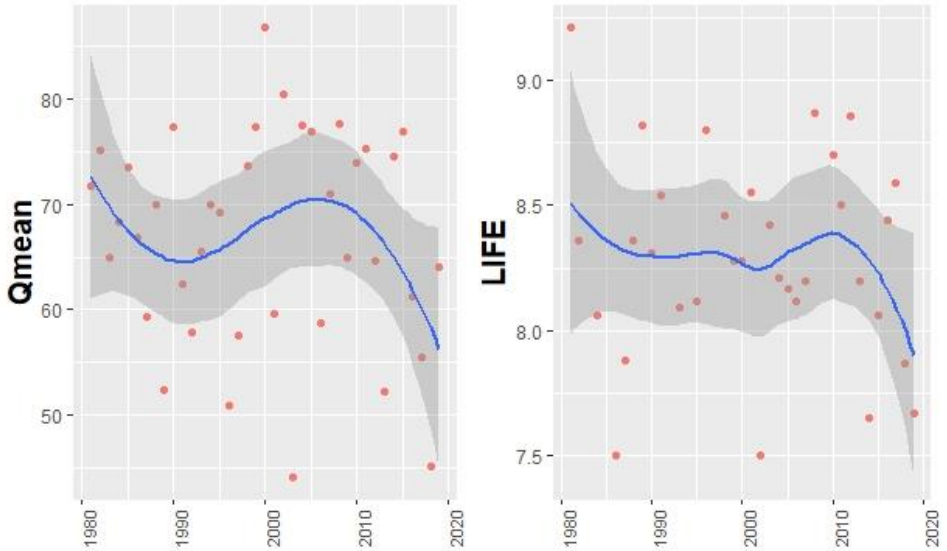
The number of scoring taxa in samples collected from the River Spey has, across most sites, increase over the study period. Most sites now have between 20 and 30 taxa per sample, which is typical of a large watercourse. The highest numbers of taxa have been recorded from the middle and lower river. The exception to this is the sites at Aberlour/Arndilly where the number of taxa has declined slightly from the numbers present in the 1980s.	

LIFE

The LIFE score has declined across the study period. This is particularly noticeable in the upper and lower river. It is however worth noting that all samples have a score of over 7 which still indicates 'good' conditions.

A comparison with the mean annual flow (Qmean) at Boat o' Brig for the same period shows that the LIFE score at Fochabers mirrors the trend in flow in the river.



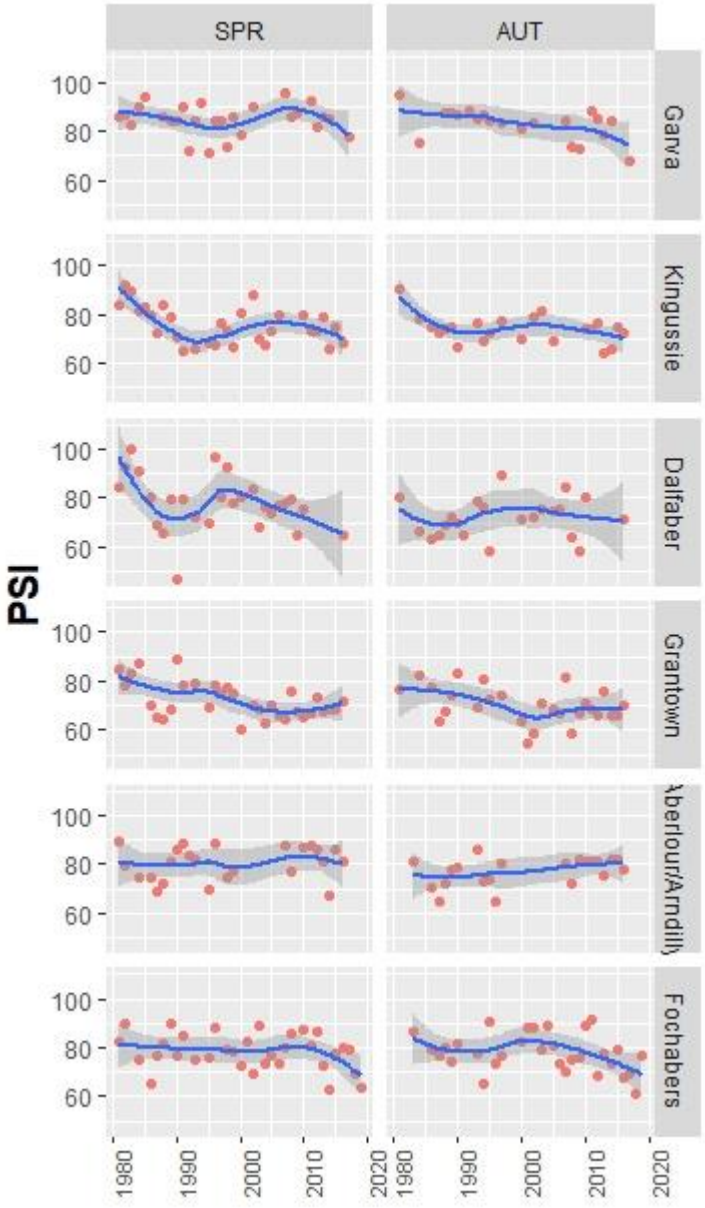


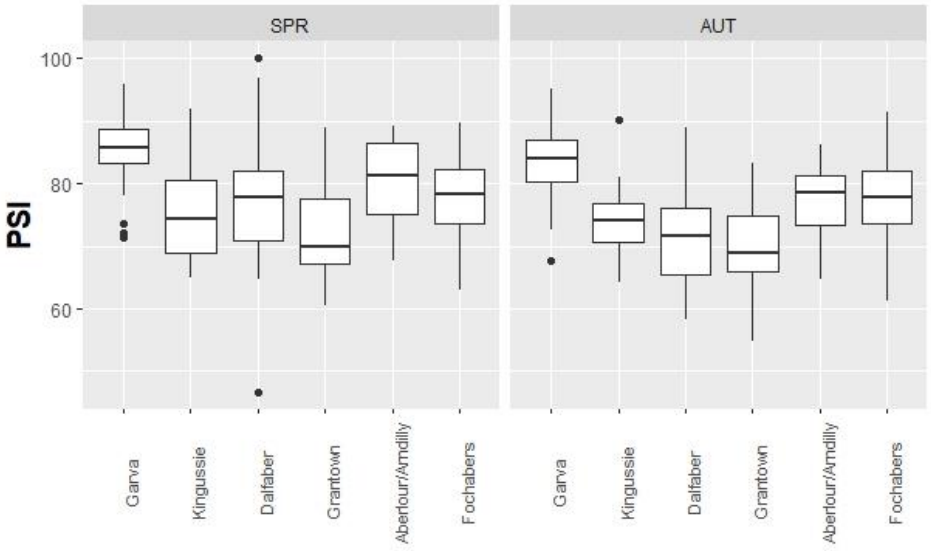
PSI

The Proportion of Sediment-sensitive invertebrates (PSI) has declined at most sites over the study period. This mirrors the trends in the LIFE score which is not surprising as lower flows will mean that any sediment in the water column will settle out more.

The exception to this general trend is at Aberlour/Arndilly where, the PSI has increased slightly, as was seen with the LIFE score.

The majority of samples have scores of over 60 indicating slight to minimal sedimentation in the river. There are six scores of below 60 which are all from the middle river and from between 1990 and 2009. These scores, which range from 46.67 to 58.54 indicate moderately sedimented conditions, however they are isolated incidences which may relate to instream or bankside works at the time, or landslips on tributaries such as happened recently on the Dulnain.

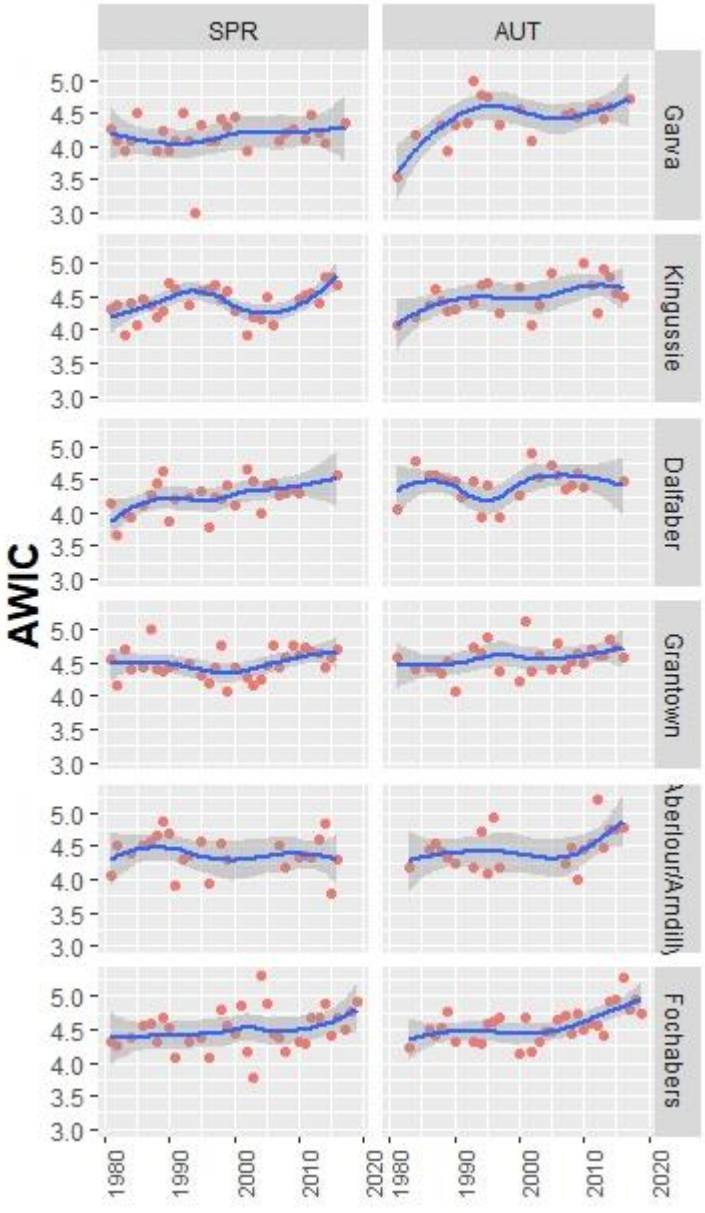


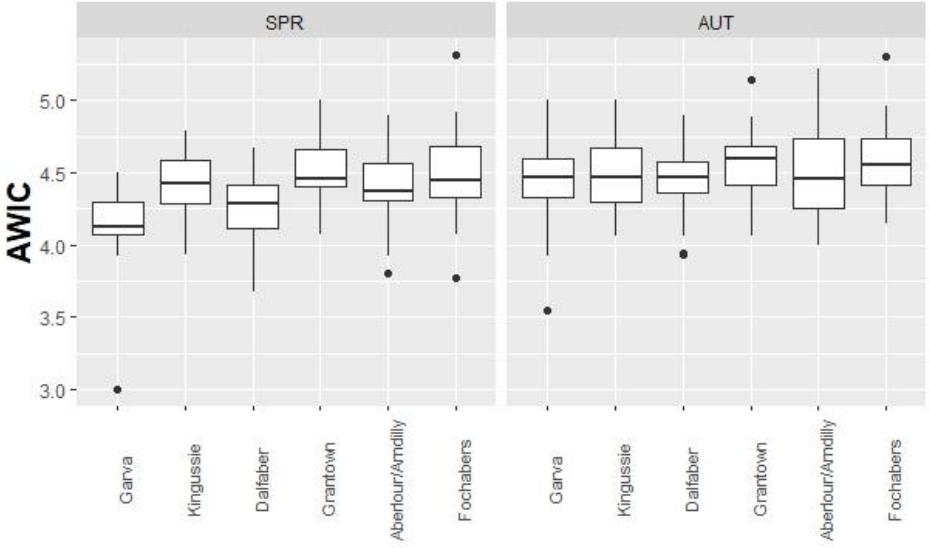


AWIC

At almost all sites the AWIC score shows an increasing trend over the study period. This suggests that the pH of the water may have increased slightly since the 1980s.

In general the AWIC averages between 4.0 and 4.5 which indicates a mean pH of between 6.98 and 7.36. There are some lower scores however these appear to be isolated episodes.

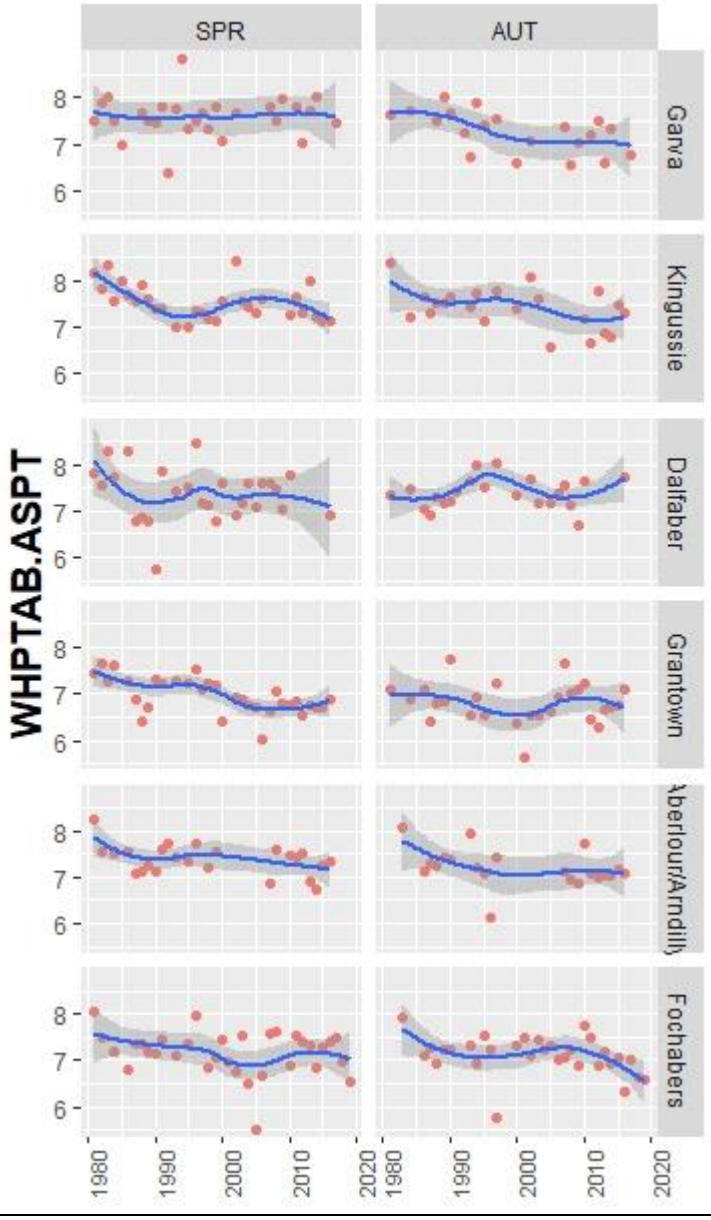




WHPT

The WHPT score gives an indication of overall ecological quality of a watercourse and reflects multiple pressure such as pollution, sedimentation and flows. As a result the WHPT follows very similar trends as those for the ASPT, LIFE and PSI scores.

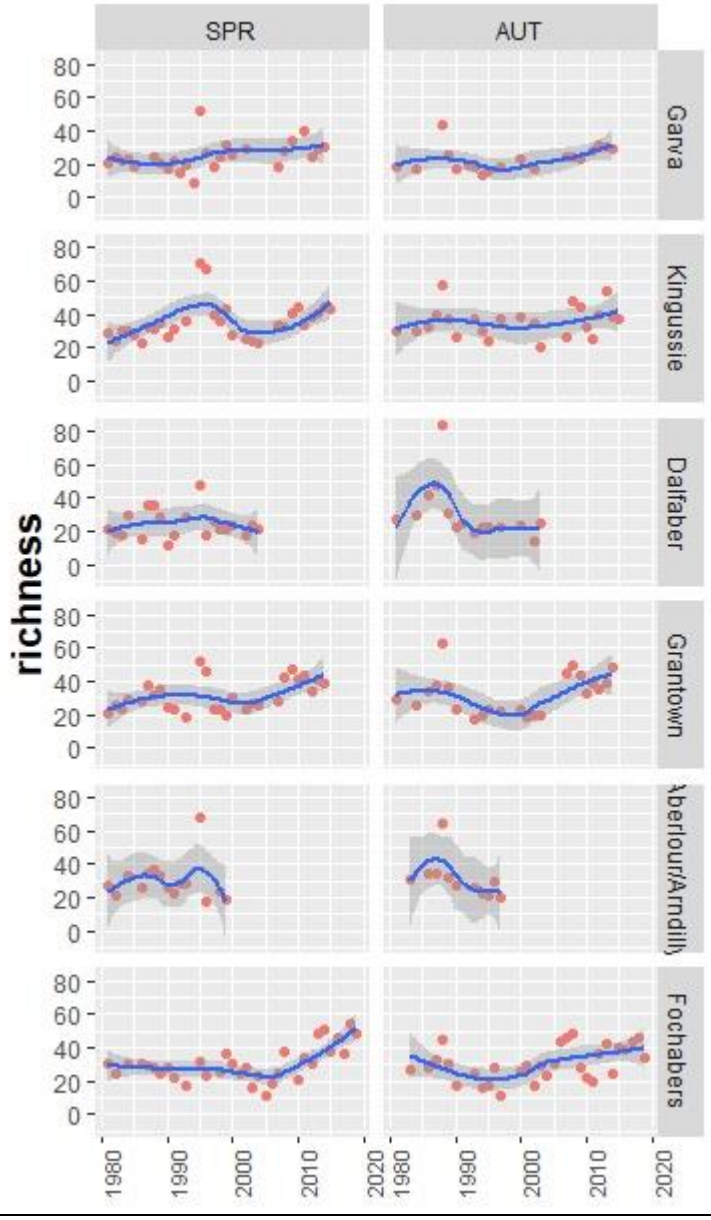
In general, the score shows a fairly even trend. There is some evidence of a slight dip in the WHPT in recent years, particularly in the autumn samples, which is probably due to the decline in the LIFE score across the study period. However, it should be noted that despite this there are only four samples that score below 6.00 across the whole 39 year study period.



Richness

Due to a change in identification precision there is insufficient data to compare trends for Dalfaber and Aberlour/Arndilly.

At other sites there are slight increases in richness in both the spring and autumn sampling events.



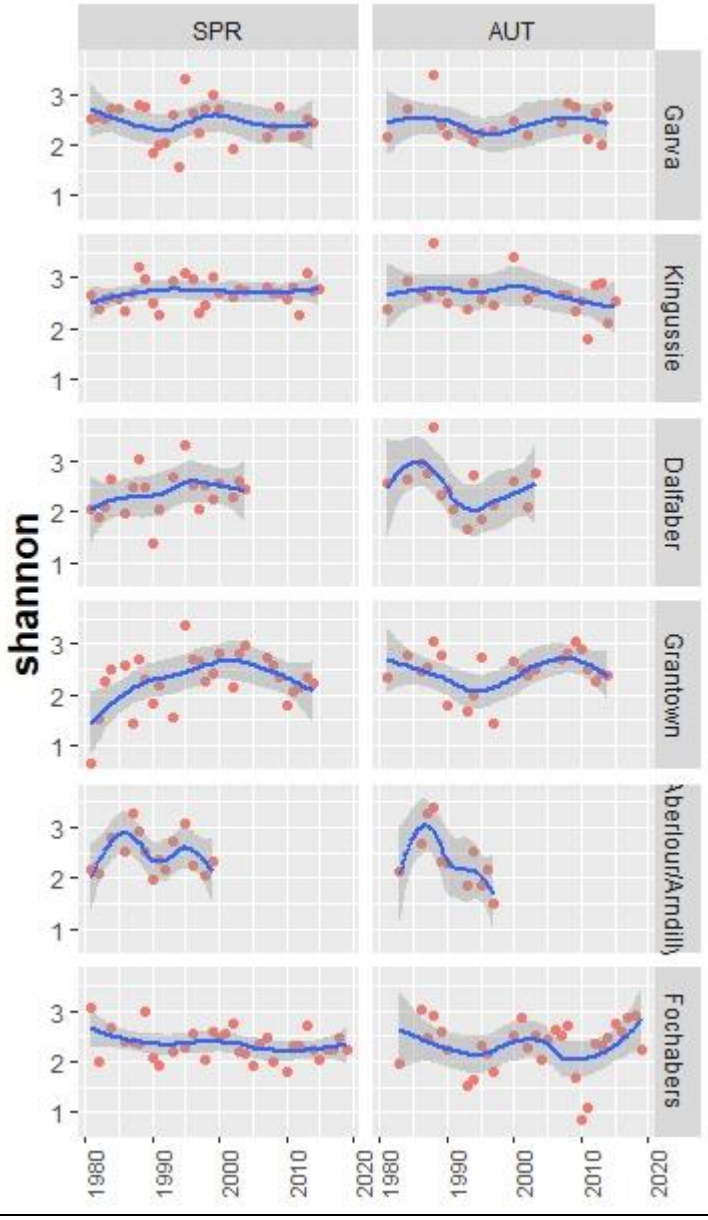
Shannon Diversity Index

Due to a change in identification precision there is insufficient data to compare trends for Dalfaber and Aberlour/Arndilly.

The Shannon Diversity in the upper river is relatively stable across the study period.

At Grantown in the middle river there appears to be a decrease in diversity in the later years however the diversity is higher now than it was in the 1990s.

The results from Fochabers in the lower river show a slight decline in diversity in the spring samples and a variable diversity in the autumn samples.



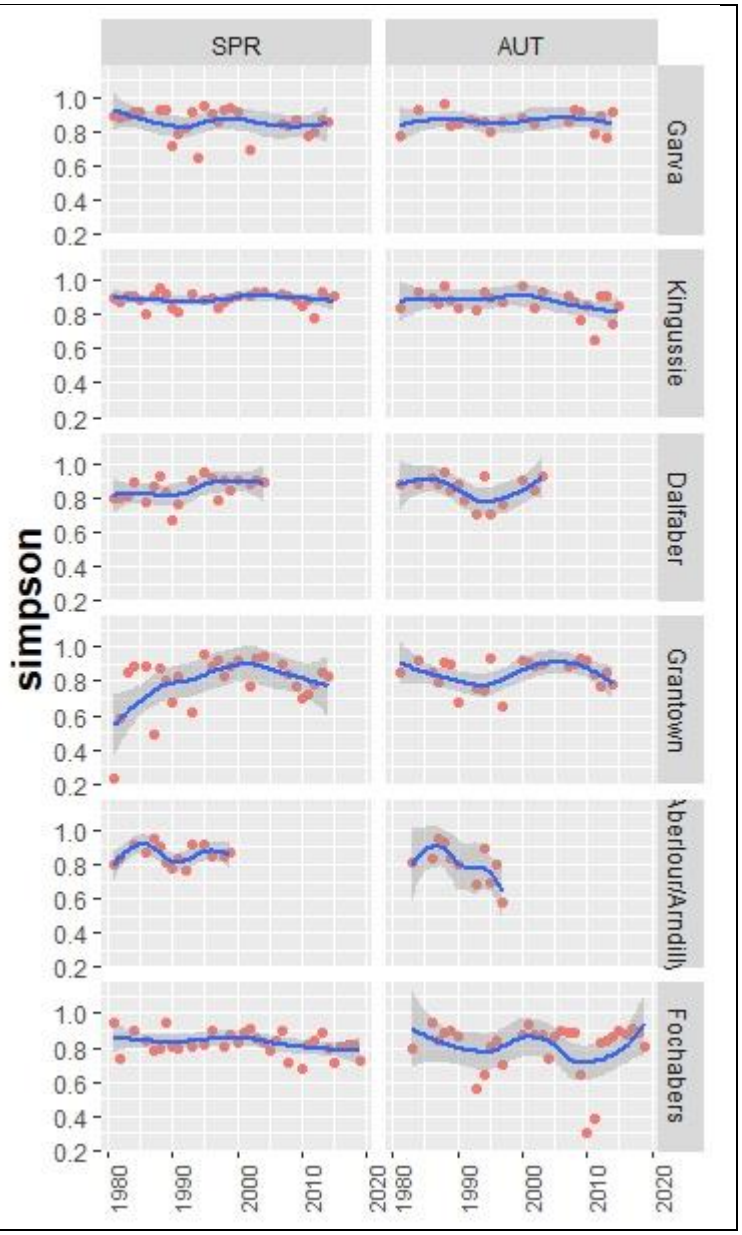
Simpson Diversity Index

Due to a change in identification precision there is insufficient data to compare trends for Dalfaber and Aberlour/Arndilly.

The Simpson diversity is relatively stable in the upper river, although there is a slight decline in the most recent years at Garva in the autumn samples.

The diversity at Grantown in the middle river shows a lot of variation in the autumn samples and a slight decline in the spring samples. It is however comparable in value to other sites on the river.

At Fochabers in the lower river the results show a slight decline in diversity in the spring samples and a variable diversity in the autumn samples.



Discussion

This study has analysed the results of invertebrate sampling at six sites on the main stem of the River Spey. The data was sourced from the Scottish Environment Protection Agency (SEPA) and covers a 39-year period between 1981 and 2019. It is not complete however, with only one site, at Fochabers having samples for each of the 39 years.

Sites were chosen to reflect conditions in the upper, middle and lower river. In addition to the site at Fochabers on the lower river, sites with sufficient data were selected on the upper and middle river. To include a second site on the lower river the results from sampling at Aberlour and Arndilly were combined. These sites are separated by just over a kilometre it was considered that the conditions at each site would be similar. However, the River Fiddich joins the Spey between these two points and may have influenced the results downstream of the confluence at Arndilly.

The taxonomic precision applied to sample identification also changed during the study period. For samples from before 2005 species level identification was undertaken for most samples. From 2005 onwards some samples were only identified to family level which means that it is not possible to produce complete trends for species at some sites. We were however able to aggregate the species level data in to families to allow trends for families to be generated for the whole period of data.

The final limitation of the data is that the abundance of invertebrate species and families has been recorded with three different methods over the 39-year period. Initially the abundance was recorded with the categories used in the Chandler Biotic Index. Between 1990 and 2004 abundances were recorded using BMWP categories based on a log scale, and after 2004 absolute abundances were recorded. To allow comparison of abundances recorded using these different methods they were standardised against the BMWP abundance categories. The Chandler categories split the BMWP categories in two, so for example 10-99 in the BMWP system covers 11-50 and 51-100 in the Chandler system. Due to the wider range of the BMWP categories it may mean that the abundance of families/species in samples recorded using other methodologies may be over-estimated, which will influence the trends derived from the data.

Overall, the Invertebrate populations of the Spey appear to be in good health. The total number of riverfly species is stable or increasing slightly and most families show increases in abundance in recent years. The total number of families and species richness both also show slight increases over time. The species diversity is also generally stable, however slight declines are evident at Grantown and Fochabers.

There is evidence in the data for a decline in abundance of some families during the 1990s, and for some these lower abundances persisted in to the 2000s. However, the abundance of most of these families has recovered to pre-1990 levels in subsequent years. This may be due to slightly different sampling methodologies, but it is not consistent across families or sites which suggests that there may have been some perturbation in conditions within the river over this period.

There was a sharp decline in Heptageniidae at Kingussie in the 1990s, a trend which is mirrored for *Rhithrogena* species. The population of Grannom (Brachycentridae) shows some variation in the middle river which may be associated with the timing of the sample visits. The absence of this family in spring samples from Dalfaber after 2007 is worthy of further investigation. Similarly, the apparent decline in the abundance of the Yellow Sally (*Isoperla grammatica*) at sites in the upper and middle river should be investigated further.

Populations of Glossosomatidae also show a notable decline in abundance during the 1990s with subsequent recovery in later years. In the middle river there are no records of this family during

much of the late 1990s and early 2000s, however they are now present at Dalfaber and Grantown in good numbers.

The presence of Sericostomatidae at Garva could signify the colonisation of this site. This is interesting and potentially significant and further investigation of the population here would be useful. In particular it would be interesting to see how much further upstream this species is found at present and monitor any further upstream expansion of its range in the upper river.

The site at Aberlour/Arndilly appears anomalous in many of the graphs. This is the only site where results from different locations have been combined for analysis, and despite the sites being very close together, the River Fiddich enters the main river between the sites. In the combined data for Aberlour/Arndilly the site at Arndilly contributes the earlier records. It is possible that the Fiddich is having a positive influence on the invertebrate assemblage at Arndilly which, when the data switches to Aberlour in the latter years creates the appearance of a decline in abundance.

The biotic indices calculated in this study show that the water quality in the Spey is very good. There are no obvious signs of problems with organic pollution or acidification. The exception to this is the site at Aberlour/Arndilly where both the number of families and the BMWP has declined slightly.

There is some evidence of lower flows influencing the composition of the invertebrate population. There is also a slight decline in the proportion of invertebrates that are sensitive to sediment, suggesting that there is slightly more sediment present in the river now, however the river is still minimally impacted by sediment.

There is also some evidence of a slight decline in the WHPT score at most sites, particularly in the autumn samples. The WHPT score gives an indication of overall ecological quality of a watercourse and reflects multiple pressure such as pollution, sedimentation and flows. As a result the WHPT follows very similar trends as those for the ASPT, LIFE and PSI scores. The downward trend noted for the WHPT score is probably related to the reduction in the LIFE score, which also appears to be impacting slightly on the degree of sediment in the river, based on the results of the PSI score. Nevertheless it must be stressed that these are very slight changes and for some sites we can have less confidence in the trend. It would however be worthwhile to monitor these scores to see if any further deterioration occurs.

Despite there being over 400 sampling events in this dataset covering a 39-year period it is disappointing that only one site, upstream of Fochabers Bridge has a complete time series of data. The sites at Dalfaber, Grantown and Kingussie come close to a complete time series however notably there are no samples at these sites since 2016. If the trends in invertebrate families and species are to be analysed again at a later date, then it is essential that these sites continue to be sampled in the future.

Recommendations

- To ensure that trends can be examined in a similar fashion in the future, continued monitoring to species level should be undertaken in the spring at the six sites featured in this study.

- Further investigations should be made at Dalfaber to understand the population dynamics of *Brachycentrus subnubilus* and whether there are any changes in the river which may be limiting the population of this caddisfly at this site.

- The apparent decline in the abundance of the Yellow Sally (*Isoperla grammatica*) at sites in the upper and middle river should be investigated further.

- The fluctuating numbers of Glossosomatidae in the middle river should be monitored to determine whether there is any link with conditions in the river.

- The distribution of Sericostomatidae in the upper river should be investigated and monitored regularly to see if this family is expanding upstream.

- Further investigation is required at Aberlour/Arndilly to understand whether the River Fiddich is influencing the results at Arndilly, and therefore the trends for this combined site.

- The WHPT, LIFE and PSI should be monitored in the future and if continued declines are noted, further investigations should be made of the possible causes.