WESTCOUNTRY RIVERS TRUST ELECTROFISHING SURVEY REPORT-RIVER AVON, 2018

River Avon

Westcountry Rivers Trust

Report written by Matthew Healey

Mapping undertaken by Holly Pearson and Craig Renton

Westcountry Rivers Trust

Rain-Charm House

Kyl Cober Parc

Stoke Climsland

Callington

Cornwall

PL17 8PH

Tel: +44 (0) 1579 372140

Email: info@wrt.org.uk

Web: www.wrt.org.uk

Blank page

Contents

List of figures

List of Tables

Executive Summary

Westcountry Rivers Trust undertook electrofishing (EF) surveys on the River Avon, Devon 2018 to monitor salmonid recruitment. Funding from South West Water (SWW) and the Avon Fishing Association (AFA) have allowed for 18 sites to be surveyed in 2018 throughout the catchment. Since the start of the SWW funded Gravel Augmentation Project in 2015 there has been an upward trend in both salmon and trout species in the Upper Catchment while catch numbers remain very poor in the lower catchment where no habitat improvement works are taking place. Using the Defend/ Repair/Attack strategy, waterbodies are assigned a plan of action based on their overall electrofishing results classification. Recommendations are made for increased survey effort throughout the whole River Avon catchment for increased knowledge of salmonid presence. Appropriate works can then be targeted to improve habitats and survival rates for salmonids at all life stages.

1. Introduction

The Westcountry Rivers Trust (WRT) has undertaken semi-quantitative fry index electrofishing surveys throughout the River Avon as part of the biological monitoring of effects of the SWW gravel augmentation project. This was the fourth year of fish monitoring for this project and the sixth successive year additional to surveys undertaken under the Catchment Restoration Fund in which monitoring began in 2013.

The dam's construction has prevented the conveyance of gravels and over time appropriately sized gravels for spawning have been washed out of the system in a natural process of downstream migration. The gravel augmentation project aims to improve spawning habitat for salmonids by replenishing gravels and using the energy of the river to sort the material into natural areas of deposition. Volumes of gravel varying between 200-300 tonnes and sized between 25mm-200mm are added at 10 sites over 4km. Gravels are transported downstream from each injection point to varying distances depending on the gradient of the river, particle size and varying flow conditions. In some cases, this can be up to 400m downstream of an injection point since project inception in 2015. Sites were electrofished prior and post augmentation to determine if there have been improvements in salmonid recruitment as a result of the additional material. Wider habitat improvements have not been undertaken due to all resources utilised in the augmentation process. Subsequent annual monitoring over the time frame of the project is allowing for the establishment of a long-term data set for River Avon salmonid recruitment.

Surveys were undertaken in July and September 2018 and a total of 18 sites were electrofished by WRT on the Avon; 12 as part of the biological monitoring of the gravel augmentation funded by SWW and 6 sites which were funded by the Avon Fishing Association (AFA) in the lower catchment.

The strength of the fry index survey is to enable a quick, affordable and semi-quantitative, catchment-wide view of the fry life stage only. As this survey is indicative of a single year, it is important to interpret the results with caution. This electrofishing survey will aid in deciding the appropriate habitat restoration works under the South West Water Gravel Augmentation project and make recommendations for third parties for habitat improvements outside of the remit of SWW.

Figure 1 below show the locations of the South West Water survey sites alongside gravel augmentation locations over multiple years and the furthest extent of particle deposition over multiple years. The full extent of particle deposition from the 2018 augmentation is not fully displayed due to walkovers not being able to place though injury to the surveyor. A survey will be undertaken for the 2019-2020 project year to monitor particle mobility as well as University of Plymouth's ongoing sediment transport surveys. Figure 2 shows the locations of all the EF surveys undertaken in 2018.

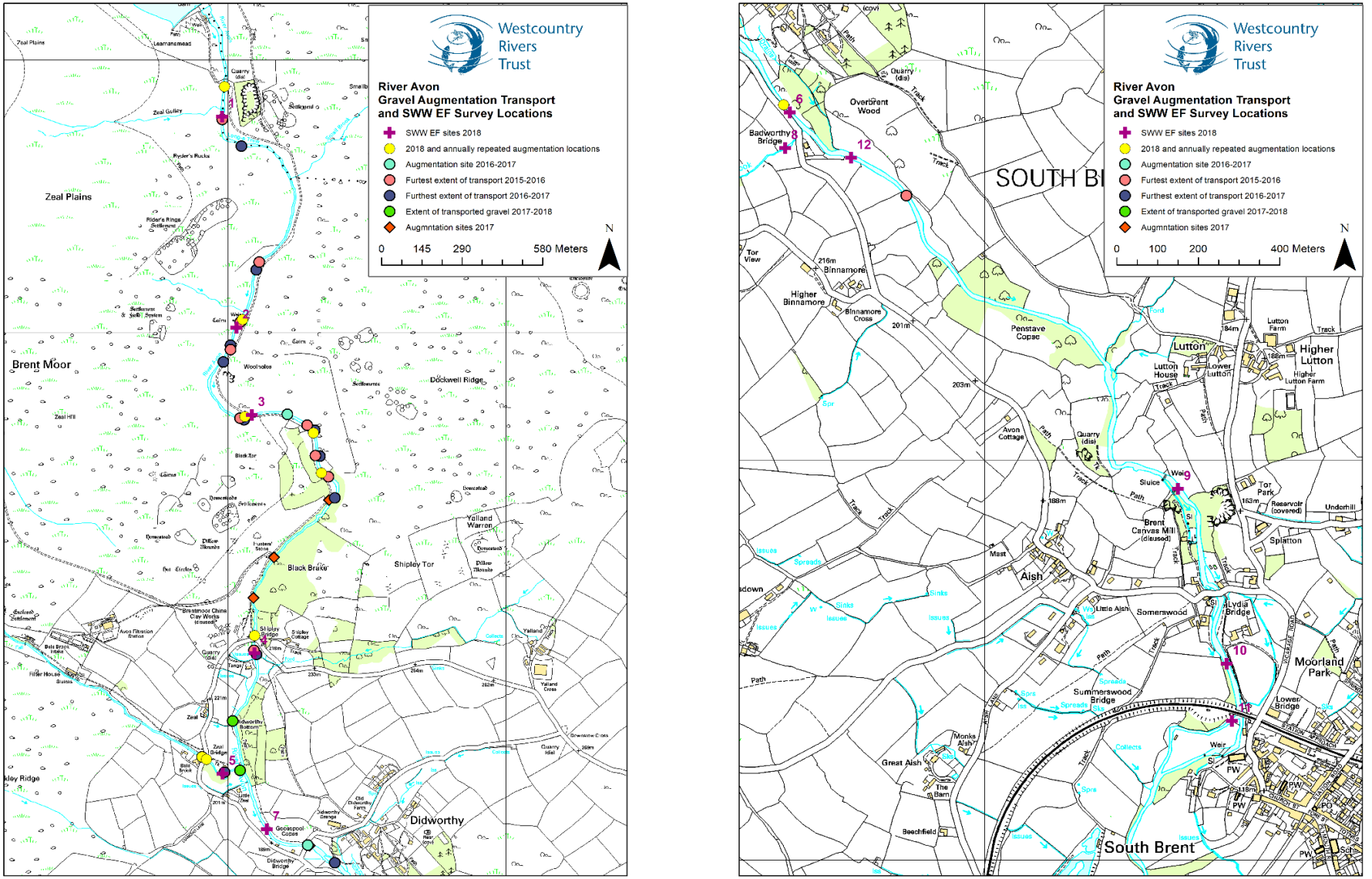


Figure 1 South West Water electrofishing survey sites and gravel augmentation locations

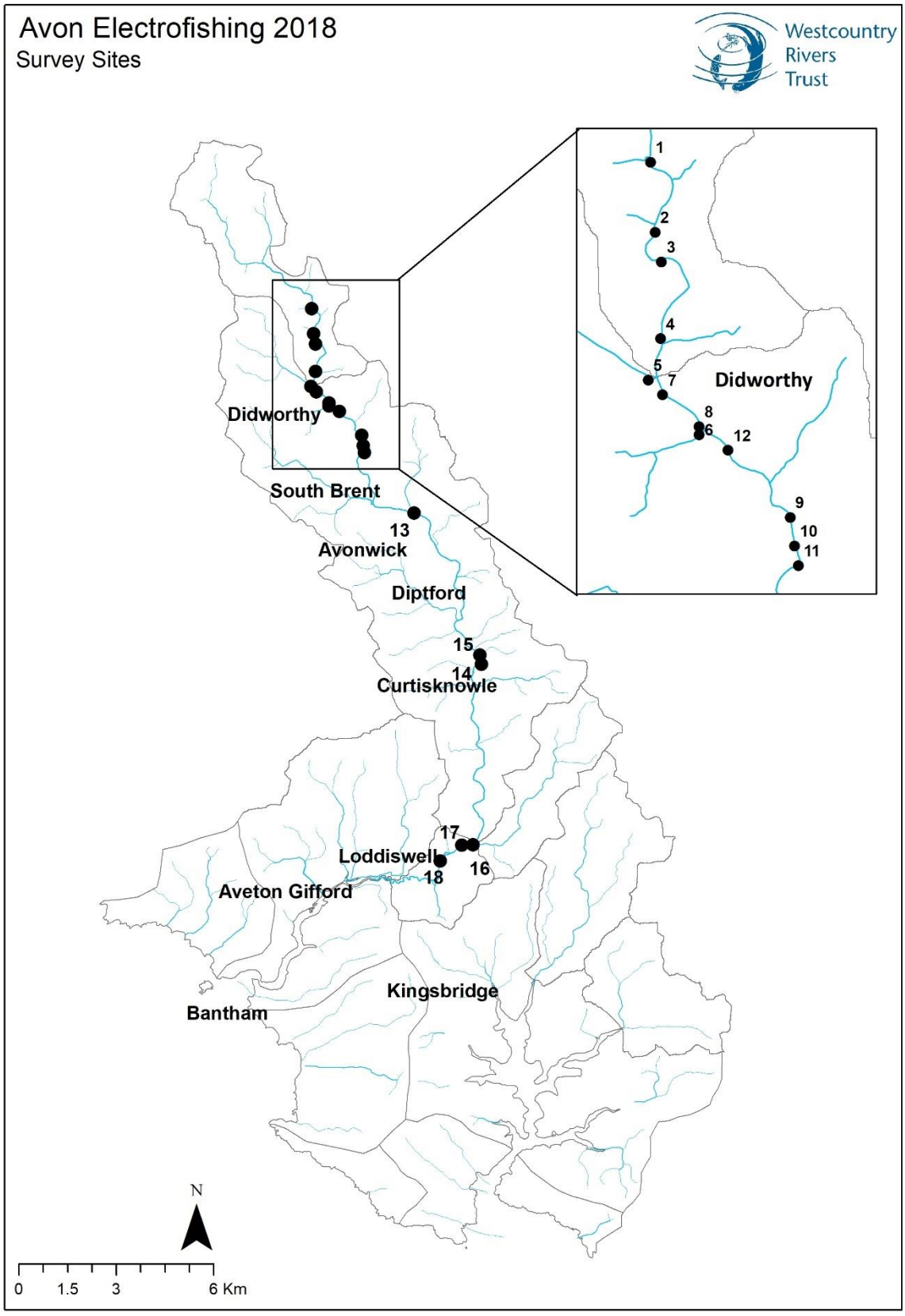


Figure 2 Map of all electrofishing survey locations, 2018

1.1 Electrofishing Protocols

Electrofishing uses a controlled electric current to induce fish to swim toward an anode and into a hand net, and thereby be counted and assessed. When carried out correctly by experienced and qualified surveyors it is not harmful to fish and the fish are released back to the same location they were caught. In upland streams and shallower sections of rivers, an electrofishing backpack is used and therefore this type of equipment was used for all the Avon surveys.

There are several approaches to electrofishing assessments in rivers; quantitative, area semi-quantitative and time semi-quantitative methodologies. All three methods have their advantages and disadvantages.

Quantitative electrofishing is a thorough methodology that has the highest degree of accuracy of all the methods. The main disadvantages of this approach are it is less mobile than backpack equipment and it takes longer to undertake surveys. It Is therefore more costly than other approaches. With this method, an area of river is netted off and the fish are removed from this defined stretch in multiple passes until sufficient fish are removed to form a very accurate assessment of species and numbers. It is not required to remove all the fish from the area but rather ensure a consistent fishing method that gives a linear decrease in the number of fish caught per pass. The overall catch decline gives an accurate estimate of the total number of fish in the location. This is known as the 'depletion' methodology.

An **area-based semi-quantitative electrofishing** methodology follows the same process as quantitative electrofishing but only a single pass is carried out. A lack of multiple passes renders the method only semi quantitative and therefore less accurate, but it has the advantage of being much quicker than the depletion method, and it is suitable for use on all waterbody types. It is able to detect multiple species and is reasonably accurate but is less time efficient and therefore costlier than a time-based methodology (described below).

A **time-based, semi-quantitative electrofishing** methodology differs from both the approaches described above. Instead of limiting the *area* fished (by use of nets) it limits the amount of *time* used to fish to assess fish numbers. As no nets are deployed, fish in deeper sections of large rivers can frequently avoid capture using this method. It is therefore only suitable to assess salmonid fry, who are restricted to a shallower section of upland streams and rivers. This method is extremely rapid and therefore cost-effective, allowing for deployment across whole river catchments although its major drawback is its lower accuracy than netted approaches.

In weighing up the pros and cons of the various approaches it is worth considering what would be required for a truly reliable method. In scientific publications it is usually considered that if an approach is accurate 95% of the time then this is an acceptable standard. Such an approach would be said to have sufficient statistical power to answer the question asked, for example, '*has this habitat improvement resulted in more fish in the area studied?*'. For an electrofishing methodology to have sufficient statistical power it requires a large number of sites to be fished in a fully-quantitative depletion methodology over a number of years. As such an effort is rarely practicable and will cost more than the habitat improvements it attempts to measure, this approach is rarely applied in the UK. River managers in the UK have limited budgets and therefore it is the case that an electrofishing programme of insufficient statistical power to achieve 95% confidence is usually accepted as a compromise between accuracy and cost.

Bearing in mind the limits of statistical power that these approaches usually have (as practically applied), it is important to consider the aim of a given electrofishing programme. In the case of WRT's catchment scale electrofishing programme, the aim is to build up historical data on each catchment to provide information as to how to best take action to improve the fish stocks for salmon and trout. To achieve this, the largest number of sites possible for maximum catchment coverage must be fished over several consecutive years to i) guide current/future conservation strategies and ii) identify whether or not the actions taken on the catchment have had a positive effect on fish numbers. Most importantly the electrofishing programme is specified to be carried out at a catchment scale where salmon and trout spawning areas occur. As most rivers have many tributaries or main stems of considerable length, a relatively large number of sites are required for full coverage. This typically equates to between 20 to 100 sites on rivers in southwest England, depending on the river catchment geography. All things considered, a timed semi-quantitative approach was considered most appropriate for the WRT electrofishing programme. This method will indicate the main issues and areas that need addressing on a river catchment including:

- Upstream barriers to fish-passage
- Degraded habitat quality
- The upper limit of salmon spawning
- Successfully/Unsuccessfully enhanced habitat
- Catchment-scale fry migration due to river levels
- Point source and diffuse pollution

1.2 Life cycle and bottlenecks

The aim of the semi-quantitative electrofishing program is to identify issues that prevent salmonids from effectively completing their life-cycle, and then proposing solutions that are proportionate to the issue at hand. It is useful to adopt certain conceptual frameworks to each of these aims, and in this report, we will use two of these frameworks; the 'habitat bottlenecks' that describe the causes of issues in salmonid ecology (figure 1), and the 'Defend/Repair/Restore' conservation strategy framework which describes the appropriate habitat action depending on the ecological situation found at the site.

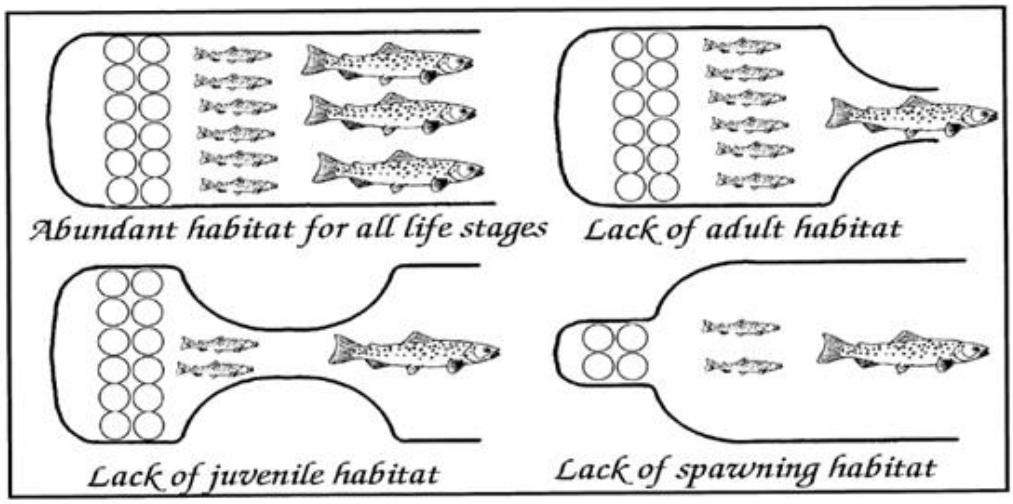


Figure 3 Diagrams defining salmonid habitat bottlenecks (Summers et al, 1996)

1.3 Catchment Based Fisheries Conservation Strategy (Defend/Repair/Attack)

In using the fry index classification, catchment population abundance monitoring and determining the river reach density classification, a series of priority areas can be outlined, and management recommendations made tailored to the particular species. Recommendation actions broadly follow the Defend/Repair/Attack concept, developed by Ronald Campbell of the Tweed Foundation. For every river reach that is classified, a management action can be loosely determined.

Whilst this provides a useful structuring framework, the reality of given situations can bring many complexities and lies on a continuum between these extremes. The goal is to move the river reaches of the Avon up from the unstable point (i.e. poor fish stocks and habitat) to the broad top of a healthy, natural riverine ecosystem. Where the populations are in a very poor state, radical actions may be required to see a change. Conversely, where the stocks are already good, habitat re-engineering and stocking operations would be inappropriate. Actions to achieve these improvements can be divided between 'fish stock actions' such as fish translocations or bag limits for anglers and 'fish habitat

actions' such as removing barriers to migration or coppicing. In many situations, both types of action will be required. This concept helps divide catchment scale management for fisheries into priorities and therefore can help to maximise multiple benefits through targeted work.

2. Site selection

Survey sites were selected to provide representative samples from distinct river reaches, characterized by habitat type, proximity to barriers and proximity to targeted restoration works under the gravel augmentation project. Sites in the upper catchment are surveyed to:

- Establish whether fry are utilising the habitats where gravels have been deposited post-augmentation and post-seasonal high flow events.
- Identify populations in tributaries where augmentation has not taken place to establish if other works to improve access and/or habitat are required and to identify salmon presence away from the main river.
- To identify the upper most range of *Atlantic salmon* on the main Avon River for purposes of targeting future works.
- Undertake surveys in the lower catchment to contribute to catchment wide data.

Sites in the lower catchment are funded by the Avon Fishing Association (AFA) and are undertaken to determine salmonid spawning presence within AFA fishing beats. The inclusion of these sites allows for insight into year on year recruitment at a wider but not entirely catchment scale.

3. Field Sampling and data analysis methods

Permissions for all sites were established before electrofishing surveys took place. Each site was electrofished by a two or three-person team. The voltage of the unit was set at each site depending on the water conductivity. The operatives fished continuously for a standard five minutes over suitable fry habitat without the use of stop nets. The fishing area was variable, and the length of fishing time was fixed. Fish were collected in a net and placed into a holding bucket before processing.

All salmonids were identified to species and fork length was measured and recorded. Numbers or density estimates were recorded for all other species captured. Habitat features such as land use, substrate type and shading were recorded at each site. Any fry that were missed or escaped during

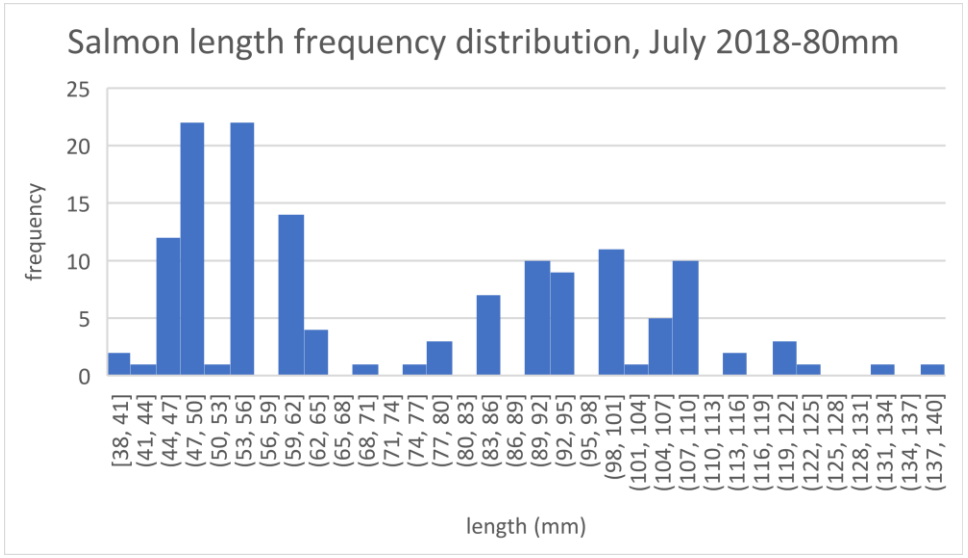
electrofishing were assigned to either trout or salmon groups depending on the relative percentage of each species already recorded at the site.

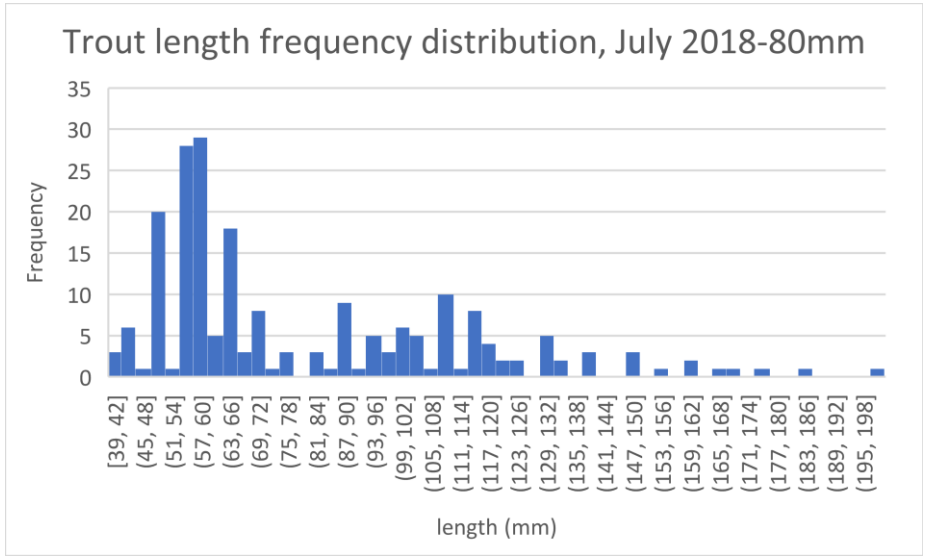
The results of the electrofishing survey are classified according to the methodology of Crozier and Kennedy (1994), displayed in Table 1, with each site being given an equivalent density classification compared to quantitative monitoring. This semi-quantitative methodology was designed by Crozier and Kennedy for both salmon and trout. However, the results for trout need adjustments to consider the difference in the regression line for trout and salmon as described by Crozier and Kennedy. This issue is planned to be investigated during the 2019 survey season.

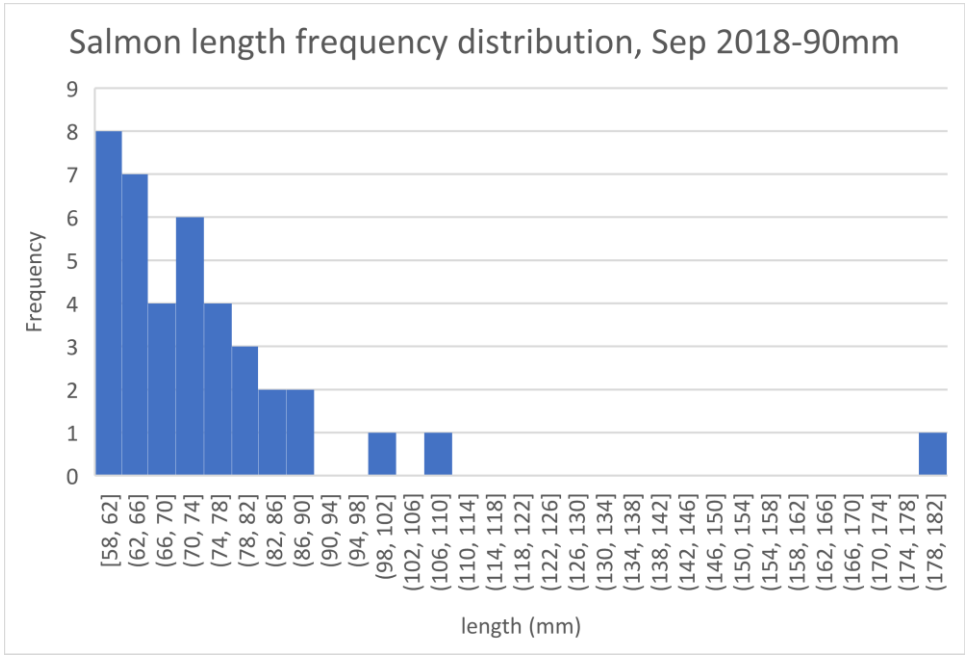
Table 1 Semi-quantitative abundance categories for salmon fry (Crozier & Kennedy, 1994)

Density Classification	**Semi-quantitative (n/5min fishing)**	**Quantitative (n 100m·2)**
A (excellent)	>23	>114.7
B (good)	11-23	69.1-114.6
C (fair)	5-10	41.1-69.0
D (poor)	1-4	0.1-41.0
E (absent)	0	0

The initial round of surveys took place in July 2018 in the upper Avon and September for the lower catchment. Fry sizes are determined from a bi-modal frequency distribution which allows for 0+ years old salmonid (this year's recruits) sizes to be determined with a small range of error either side of the size split. Fry sizes in the upper catchment for salmon and trout were estimated at 80mm. Fry sizes in the lower catchment were larger given the surveys were undertaken later in the year; salmon 0+ years were 90mm and trout 0+ years were 100mm.







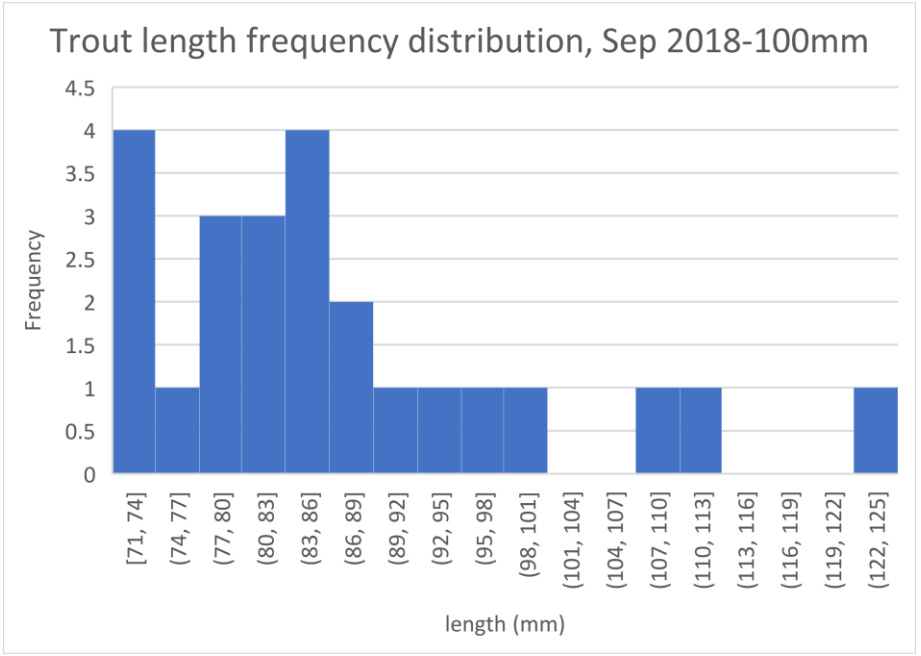


Figure 4 Salmon and Trout length frequency distribution on for the River Avon, 2018

4. Results and Discussion

Table 2 gives an overview of salmonid fry results for all sites surveyed in 2018. In total 12 sites were surveyed in relation to the gravel augmentation project (see figure 1) and 6 sites were surveyed for the AFA. A total of 133 0+ years salmonids were recorded over 18 survey sites. The length of all fish caught ranged between 39mm and 198mm but only 0+ fry sizes as can be seen in figure 2 are used in the classification.

Salmon were absent at 8 of the survey sites but 3 of those sites are deemed inaccessible due to natural barriers. Salmon have never been recorded at those sites in a WRT or Environment Agency (EA) electrofishing survey. A new site downstream of the Badworthy augmentation EF site (the lowest downstream augmentation site) was included this year to help determine a reason for a "Poor" classification at Badworthy. This site, although never fished before, has been improved by the gravel augmentation works but a classification of "Poor" was also recorded highlighting a disappointing year for salmon above Lydia Falls. Crackhill Weir was classified as "Good" while the two sites in South Brent were both "Excellent", the site downstream of Lydia Falls returning the highest catch numbers of all surveys. Humpy Bridge was classified as "Good" while salmon numbers reduced farther down the catchment, with only the survey site upstream of Curtisnowle Weir being "Fair". The remaining sites downstream of Avonmill and Newbridge were classed as "Poor" or "Absent".

Trout were present at every site except two in the lower catchment, with any "Fair" or "Poor" results possibly relating to a salmon dominance or less trout-suitable sites. Badworthy Stream had an "Excellent" classification for trout this year with the remaining sites in the upper catchment split equally between "Good" and "Fair". Only one site in the upper catchment was classed as "Poor" while the lower river is quite the opposite with the majority of sites classed as "Poor" or "Absent" classifications.

Table 2 2018 Avon EF site classification table

	Site ref:	Site no.	2018 salmon fry class and catch no.	2018 trout fry class and catch no.
SWW sites	d/s dam (A)	1	E*	C-6
	d/s Old abstraction (A)	2	E*	B-21
	Woolholes Bridge (A)	3	E*	B-11
	d/s Shipley Bridge (A)	4	E	B-15
	Bala Brook (A)	5	E	C-10
	Badworthy Stream	8	E	A-28
	Goosepool Copse	7	E	C-6
	Badworthy (A)	6	D-4	B-12
	d/s Crackhill Weir	9	B-12	D-3
	Lydia Bridge	10	A-44	C-6
	Brent Island	11	A-26	C-9
	d/s Badworthy	12	D-2	B-22
AFA sites	Humpy Bridge	13	B-20	C-5
	u/s Curtisknowle weir	14	D-2	D-1
	d/s Curtisknowle weir	15	C-9	D-1
	u/s Avon Mill	16	E	E
	d/s Avon Mill	17	E	D-1
	Newbridge	18	E	E

N.B. E* in dark red denotes sites where salmon have never been found in surveys and therefore sites are likely to be inaccessible to salmon due to natural barriers.

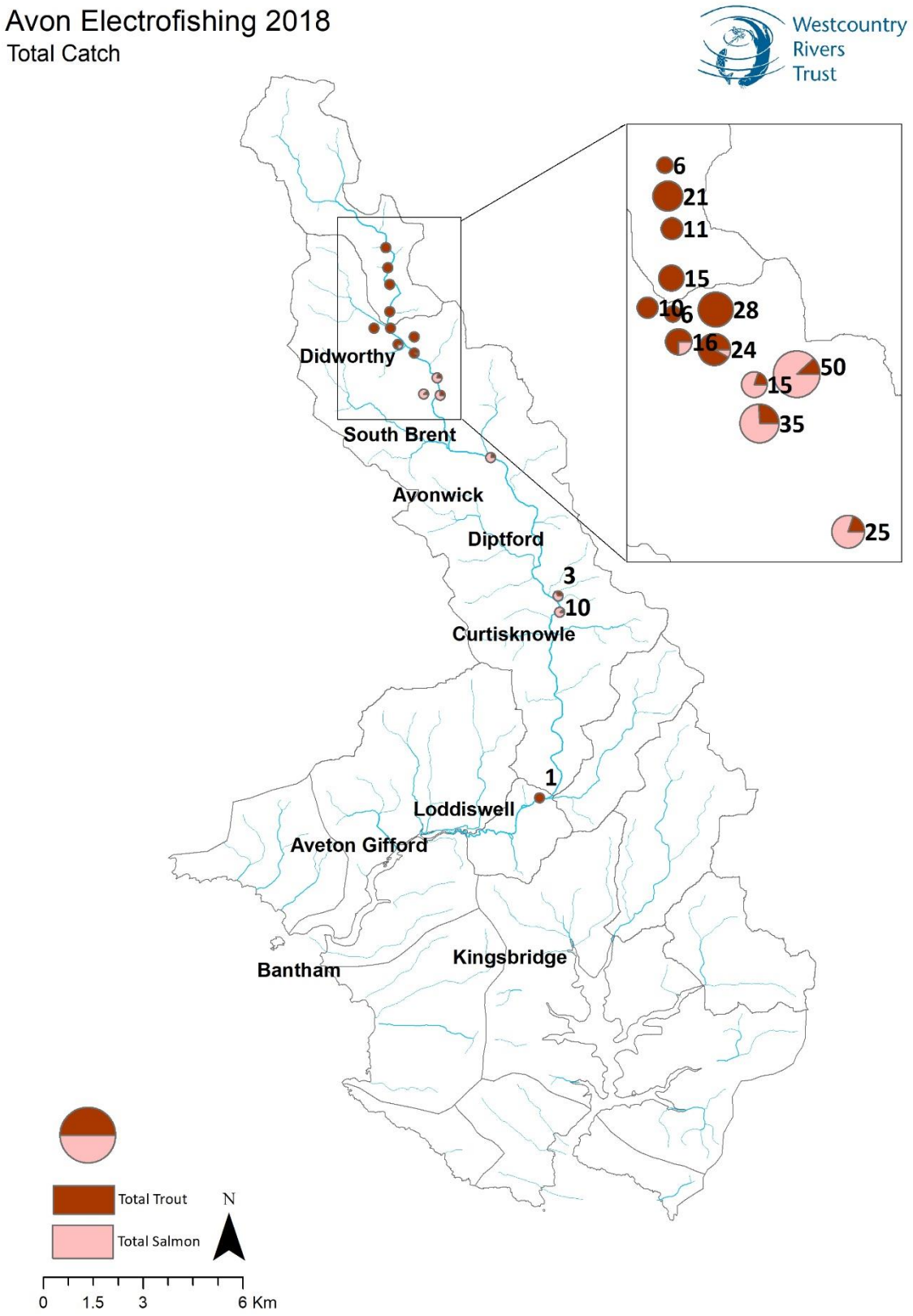
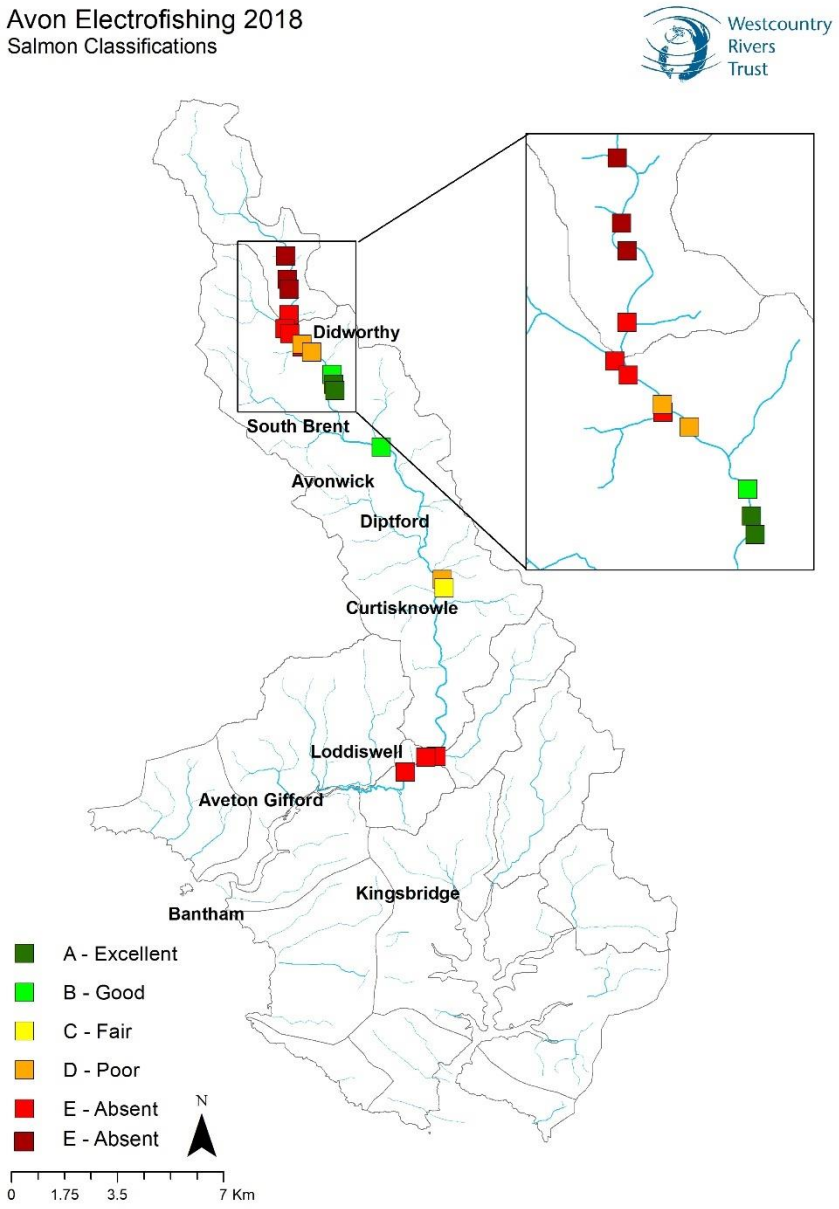


Figure 5 Total catch data for River Avon, 2018



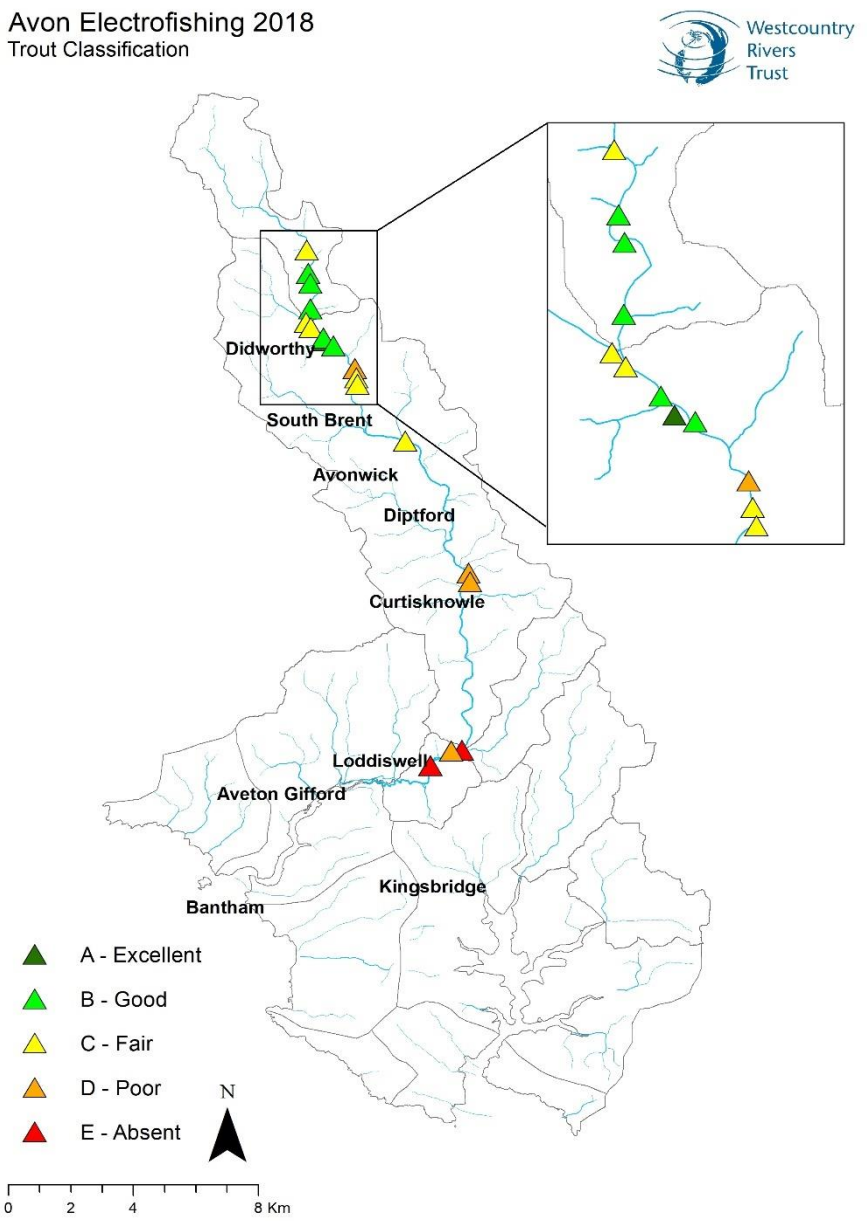


Figure 6 Salmon and trout classifications for River Avon, 2018

Salmon results in the upper Avon are unlikely to change in the short-term at sites 1-5 & 7 above Badworthy. This is because there is minimal spawning habitat for salmon, the natural barrier to upstream migration at Shipley Falls and the movement of gravels downstream to improve spawning habitat as part of the augmentation project will depend upon rate of particle transport from the very upper reaches of the Avon and volume of material augmented. With the low flows experienced for much of 2017, it is likely that salmon migration over Lydia Falls was restricted to only the strongest of swimmers. Overall, fry numbers have increased over recent years in the augmented sites in the upper Avon and the control sites at South Brent are returning consistently to "Excellent" or "Good" results. The low catch numbers at Badworthy were disappointing, the most successful of augmentation sites for salmon. Only four were caught this year, again possibly as a result of low flows limiting migration but numbers may also have been affected by the cold spell in spring 2017. Subsequent snow melt, leading to very high flows, could potentially have led to increased mortalities of juveniles but it's likely a combination of the above factors led to a poor result. For comparison, a new site was fished approx. 800m downstream of the Badworthy to determine if adult salmon may have used other areas for spawning or whether fry had moved much further downstream owing to environmental conditions. Only two salmon fry were caught at this site leading to an assumption that migration was limited in the winter of 2017 with perhaps a high mortality rate. Annual variations in recruitment are to be expected and it is not yet known how long the improved habitat from the augmentation is stable for. Some variation in available spawning habitat could also be a factor, especially in such a high energy location.

Surveys in the lower catchment undertaken for the Avon Fishing Association were, again, disappointing. The site near Humpy Bridge was clearly the best with most of the fry being found within macrophytes rather than the gravels. This highlights the importance of plant growth within the river for refuge and food. Numbers upstream and downstream of Curtisknowle Weir were once again disappointing for what is potentially good fry habitat sites for both salmon and trout. There are many factors that could be affecting recruitment here; either the spawning habitat is not suitable so there are very few eggs, juvenile habitat is degraded or lacking and so needs improvement, and/or the reach revetments on both sides of the river from previous industrial activities is leading to an unnaturally straight and wide channel with reduced diversity in habitat. The weir at Curtisknowle has been slightly damaged by a large tree which may be affecting flows down the Larinier fish pass, potentially reducing its efficiency. The damage has been reported to the EA for investigation. Trout fry numbers are not expected to be high at these sites given they are in the main river which is preferable for salmon, so any management would need to consider improvements for salmon specifically.

Table 3 Multiyear Salmon fry classifications (N.B. Dark red area denotes sites inaccessible to salmon and therefore absent). (A) is an augmented site).

			Salmon fry class and numbers caught					
	Site ref:	**Site no.**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
SWW Sites (WRT)	d/s dam (A)	1	E	E	E	E	E	E
	d/s Old abstraction (A)	2	New site for 2017				E	E
	Woolholes Bridge (A)	3	E	E	E	E	E	E
	d/s Shipley Bridge (A)	4	New site for 2016			E	E	E
	Bala Brook (A)	5	New site for 2016			E	E	E
	Badworthy Stream	8	New site for 2016			E	C-6	E
	Goosepool Copse	7	New site for 2016			E	E	E
	Badworthy (A)	6	D-1	E	B-15	C-10	B-21	D-4
	d/s Crackhill Weir	9	D-2	D-1	C-7	D-4	C-6	B-12
	Lydia Bridge	10	B-16	B-19	C-7	A--38	A-36	A-44
	Brent Island	11	C-9	B-16	C-7	B-17	B-22	A-26
	d/s Badworthy	12	Investigative site for 2018					D-2
AFA Sites (WRT)	Humpy Bridge	13	New site for 2016			E	Incomplete	B-20
	u/s Curtisknowle weir	14	New site for 2016			E	D- 3	D-2
	d/s Curtisknowle weir	15	Not fished	C-9	Not fished	D-4	C- 9	C-9
	u/s Avon Mill	16	New site for 2016			D-1	Incomplete	E
	d/s Avon Mill	17	D-1	D-4	Not fished	E	E	E
	Newbridge	18	New site for 2016			Not fished	Not fished	E
			Results pre-augmentation		Catch results post-augmentation			

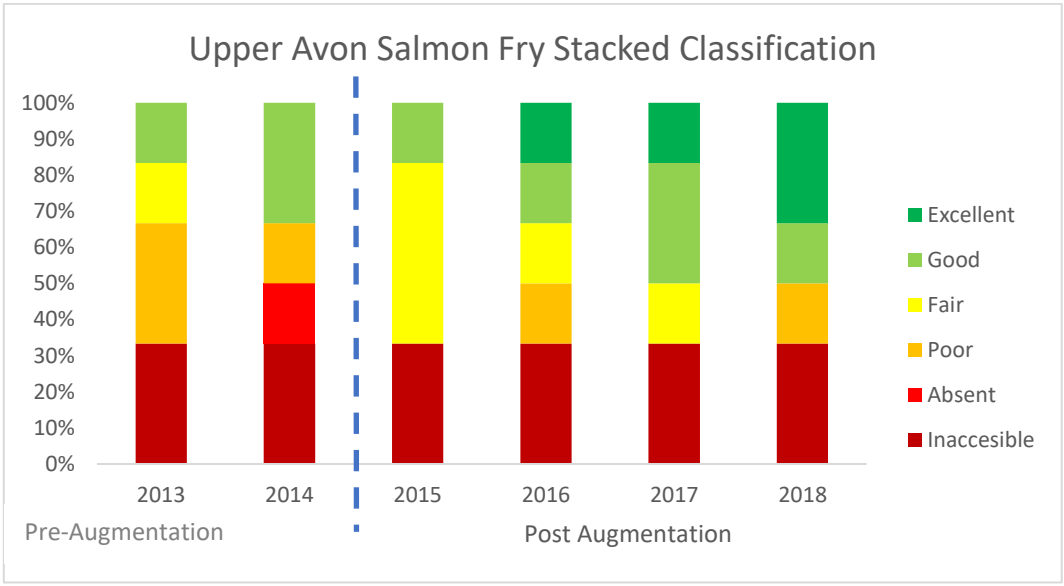


Figure 7 Classifications for salmon as a percentage of sites fished from the year 2013 - 2018 (N.B. Dark red area denotes sites inaccessible to salmon and therefore absent). Data is taken from results at augmented sites 1,3 and 6 and non-augmented sites 9,10 and 11.

Trout numbers are looking consistent overall with an upward trend over the past 6 years. Higher than expected numbers were caught at Shipley Bridge and Woolholes Bridge. This is possibly due to a higher rate of deposition and then particle stability following a dry water year. Numbers were unsatisfactory on the Bala Brook and downstream of the dam this year and this is thought to be (somewhat contradictory to the previous statement) due to the movement of gravels at these sites out of the channel. In the case of the Bala Brook, gravels are becoming much more widely dispersed and are nearly reaching the confluence of the Avon. The investigative site downstream of Badworthy proved favourable for trout fry, highlighting that the gravels are improving habitat for some distance along this reach and, in the absence of salmon, they have had a successful season. It is not known at this stage whether the site will be revisited in 2019. The lower Avon sites are not expected to yield high numbers of trout. It is quite normal for the greater numbers to be in the upper reaches of the river and on tributaries which have favoured flow type and habitat.

The following table and graphs show comparative data for existing continuously surveyed WRT sites. These annual comparisons allow for assumptions to be made with regards to catch numbers and what may affect them when factors such as flow, habitat change, and anthropogenic impacts are taken into account. In the upper catchment these comparisons are of particular interest with regards to results pre- and post-gravel augmentation.

These results do not yet provide a dataset long-term enough to observe trends, but they do show annual fluctuations in recruitment and how they vary based on environmental parameters. They will provide useful information in the future, allowing the targeting of improvements where negative trends prevail, offering insight into potential reasons for poor results and highlighting the type of works that would be beneficial to particular salmonid life stages.

Table 4 Multiyear trout fry classifications. (A) is an augmented site

			Trout fry class and numbers caught					
	Site ref:	**Site no.**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
SWW sites	d/s dam (A)	1	D-4	E	D-3	B-13	B-14	C-6
	d/s Old abstraction (A)	2	new site for 2017				GB- 12	B-21
	Woolholes Bridge (A)	3	D-1	D-1	C-7	C-5	D-4	B-11
	d/s Shipley Bridge (A)	4	New site for 2016			D-4	D-3	B-15
	Bala Brook (A)	5	New site for 2016			B-13	B-22	C-10
	Badworthy Stream	8	New site for 2016			B-15	A-36	A-28
	Goosepool Copse	7	New site for 2016			C-6	C-7	C-6
	Badworthy (A)	6	D-3	C-7	D-4	C-10	D-3	B-12
	d/s Crackhill Weir	9	D-3	B-20	B-19	C-8	GB-19	D-3
	Lydia Bridge	10	E	C-6	C-9	Poor-3	C-9	C-6
	Brent Island	11	D-2	B-13	C-5	C-6	B-13	C- 9
	d/s Badworthy	12	Investigative site for 2016					A- 22
AFA sites	Humpy Bridge	13	New site for 2016			E	Incomplete	C-5
	u/s Curtisknowle weir	14	New site for 2016			D-1	D-3	D-1
	d/s Curtisknowle weir	15	Not fished	Fair-5	Not fished	E	D-2	D-1
	u/s Avon Mill	16	New site for 2016			E	Incomplete	E
	d/s Avon Mill	17	E	E	Not fished	E	D-2	D-1
	Newbridge	18	New site for 2016			Not fished		E
			Results pre-augmentation		Results post-augmentation			

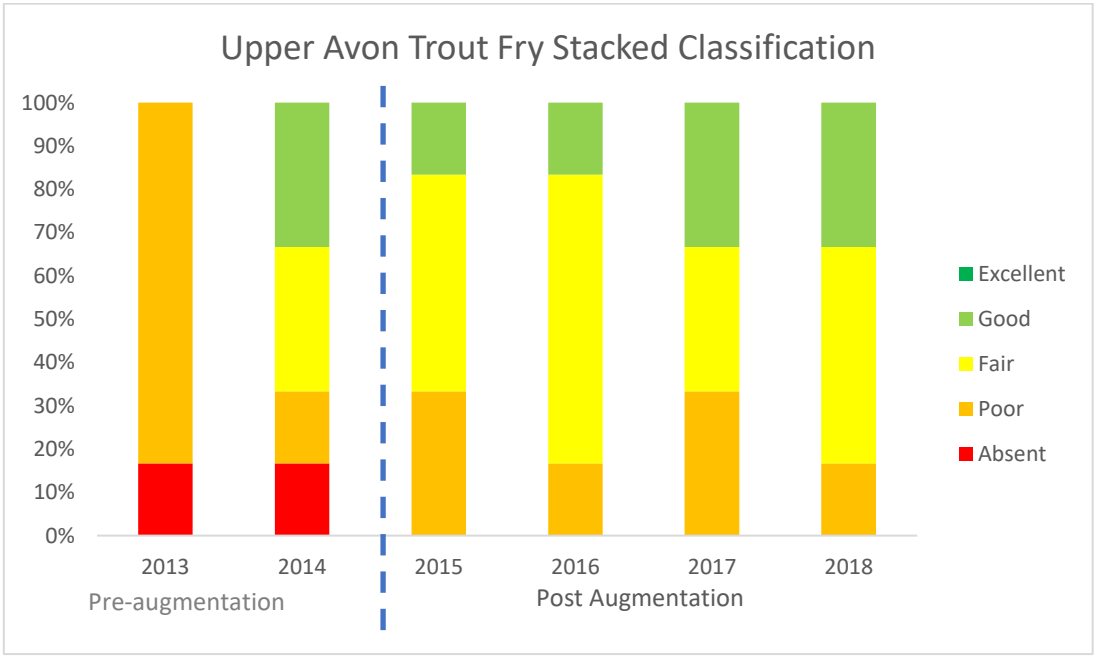
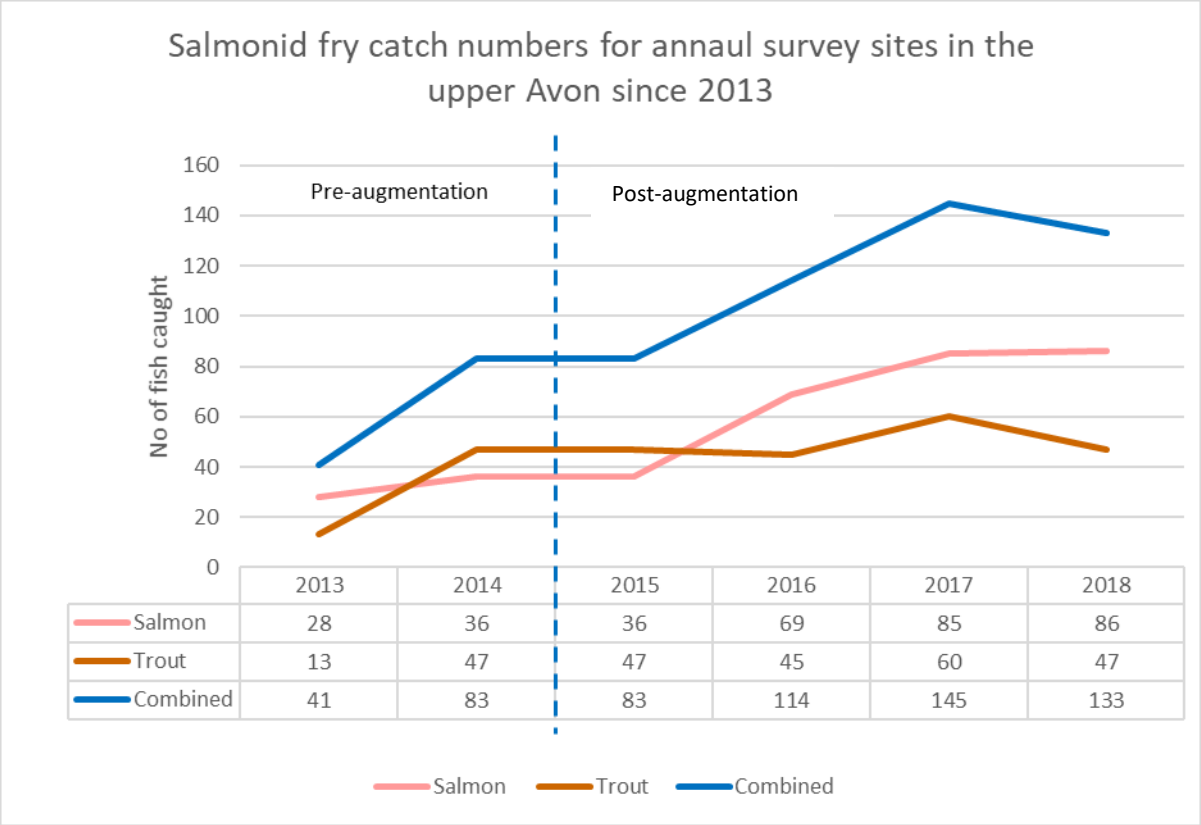


Figure 8 Classifications for trout as a percentage of sites fished from the year 2013 – 2018. Data is taken from results at augmented sites 1,3 and 6 and non-augmented sites 9,10 and 11.



	2013	2014	2015	2016	2017	2018
Salmon	28	36	36	69	85	86
Trout	13	47	47	45	60	47
Combined	41	83	83	114	145	133

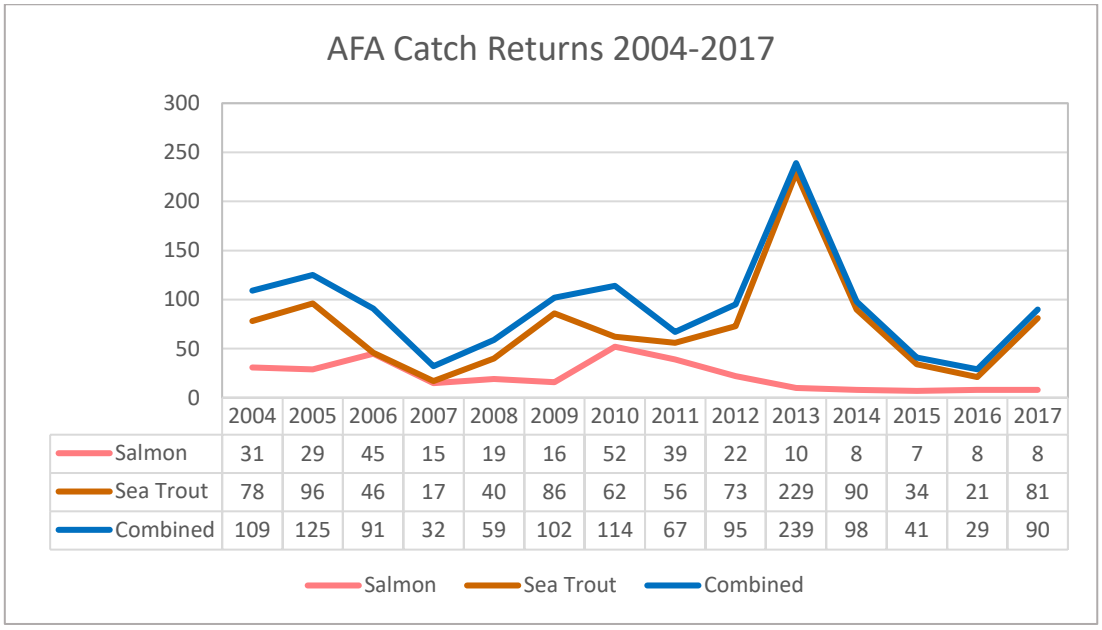
Figure 9 Total catch numbers for the 6 long term surveys sites 1,3,6,9,10 and 11, upper Avon showing an overall upward trend for salmonids

5. Recommendations

The maps in figures 9 have taken the classifications from the surveys and incorporated them into distinct EA waterbodies within the Avon catchment. Although the EF surveys are undertaken for recruitment of salmon and trout, they have slightly different habitat preferences and one species will often dominate over the other where the other has limited or no presence. Therefore, management strategies need to be considered for each species, hence a conservation strategy for both salmon and trout.

It is also important to remember that the number of surveys on the River Avon are limited and therefore are not truly reflective of a catchment wide survey. The number of locations surveyed are restricted by a lack of available resources to undertake full catchment surveys and so the recommendations for conservation are made by using the data available and current knowledge of the catchment. By utilising data from the EA and the Avon Fishing Association (AFA) we can also consider trends for all life stages rather than fry alone.

The graph in figure 7 shows AFA catch returns over a 13-year period which allows this catch data to be taken into consideration in the overall strategy (catch data from the AFA). The trends here are downwards, with only a better year for sea trout catches in 2017, marking an upward trend overall for trout. These downward trends show that lower catch numbers could be related to low numbers of returning fish due to poor recruitment in previous years, as well as impacts at sea which are difficult to combat but there will also be variable figures based on the fishing effort per annum. Netting in the Avon estuary has been an issue in the past, but recently introduced byelaws are aiming to help combat the problem.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Salmon	31	29	45	15	19	16	52	39	22	10	8	7	8	8
Sea Trout	78	96	46	17	40	86	62	56	73	229	90	34	21	81
Combined	109	125	91	32	59	102	114	67	95	239	98	41	29	90

Figure 10 AFA catch data from 2004-2017

The strategy for restoration and conservation of sites suggested here broadly follows the "Defend, Repair, Attack" (DRA) concept (Table 5) developed by Ronald Campbell of the Tweed foundation, and has, in the past, been applied locally in the Exe catchment by the River Exe and Tributaries Association project. The fry productivity of the rivers is assessed by a combination of historic semi-quantitative electrofishing results, along with EA netted electrofishing sites added to this report at a later date. These results are then applied in context of existing plans (e.g. Salmon Action Plan, habitat walkover surveys and genetic data) to produce assessments and recommendations for each sub-catchment of the river. These sub-catchments are classified according to three levels: *Defend*, *Repair*, and *Attack* (table 6 below).

Despite the DRA strategy being a useful tool to identify and prioritise works in catchments, the requirements of waterbodies can rarely be quite so clear cut. The coloured arrow in table 6 represents the continuum of the three strategies and the goal for each waterbody; to move all the Avon sites

from their current position to somewhere in the *Defend* category, or to ensure they remain in this status if fish stocks are already good.

Table 5 Defend/Repair/Attack strategy

Category	Status	Action
Defend	These areas have **good** fish stocks and habitat and **need safeguarding** actions to ensure no decline occurs.	**Maintain bag limits** **Habitat Safeguarding**
Repair	These areas have **moderate** fish stocks, and fish habitat in a moderate condition; these areas **need assisted habitat recovery** to move them into the Defend category.	**Catch and release** **Assisted habitat recovery**
Attack	These areas have **poor** fish stocks, and the habitat is significantly degraded. These areas **need drastic intervention** such as habitat reengineering in order to improve their status.	**Stock action** **Habitat re-engineering**

Table 6 River Avon sub catchment classification and DRA strategy

Sub catchment	Average Fry Index Class & Conservation Strategy	
	Salmon	Trout
Upper Avon	Absent Attack	Good Repair/Defend
Avon- Upper	Fair Repair	Good Repair/Defend
Avon- Lower	Absent Attack	Absent Attack

Upper Avon Salmon fry are not recorded above Didworthy due to natural barriers at Shipley Falls and poor spawning habitat between the augmentation sites at Shipley Bridge and Badworthy. However, an Attack strategy is being utilised here with the addition of suitably sized spawning gravels until 2020 which is improving habitat further downstream at sites where salmon are present. There is no intention of improving access over naturally occurring barriers to migration. Trout numbers have improved here since the gravel augmentation project which are the key indicator species above

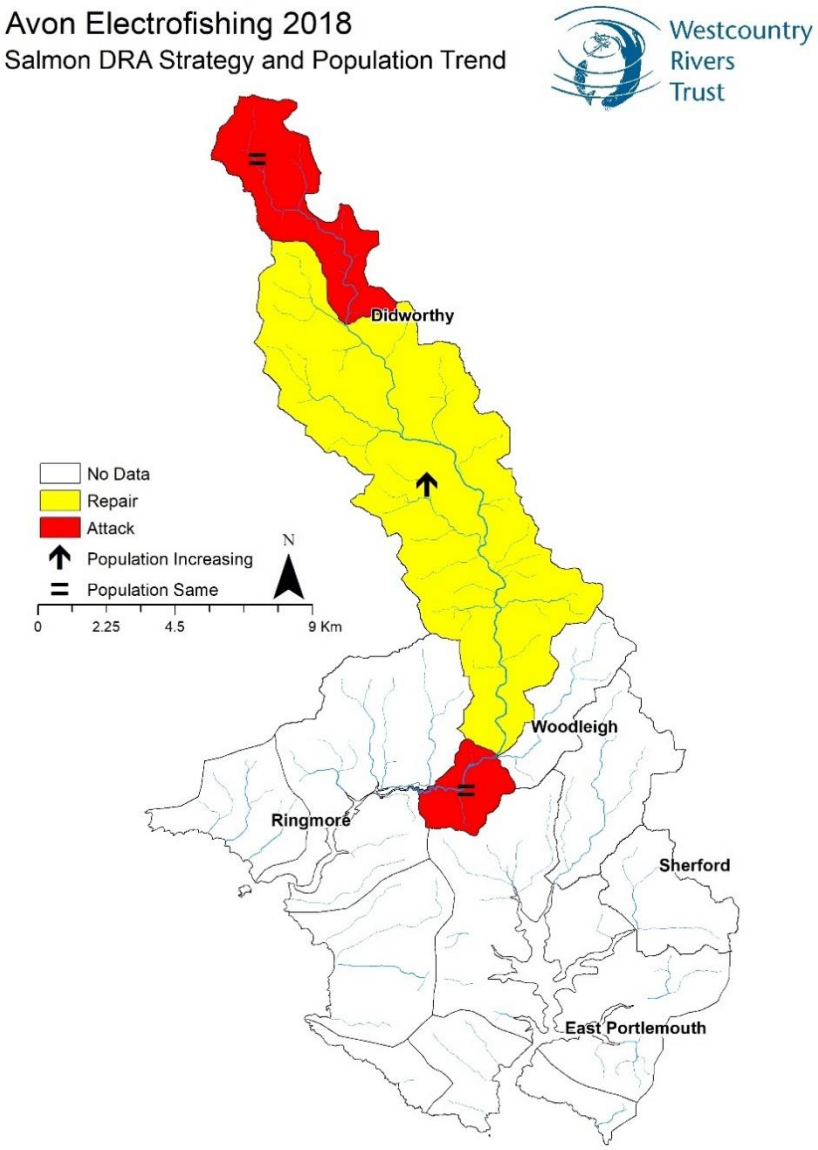
Shipley Falls. It has been noticed however that the instability of gravels and loss of previously improved habitat can lead to a fall in catch numbers and so to defend these numbers, actions such as hinging riparian trees into the river to slow the downstream movement of gravels is recommended as is the continuation of augmentation.

Avon-Upper Increased survey effort is needed in this waterbody to accurately reflect salmonid presence. Habitat improvements should be made here with additional light to riffles and instream refuge to protect any increase in fish numbers and offering refuge from avian predators for all life stages. Any barriers to migration to be continuously observed. The AFA already incorporate a catch and release policy for salmon.

Increased survey effort in the form of walkovers and potentially EF'ing is recommended in this waterbody, particularly in the tributaries where trout can flourish with appropriate riparian management. Although classed as a defend action, the lack of surveys and wider information on fish numbers dictates that a repair strategy is needed.

Avon-Lower Continuously absent or Poor results reflect the need for action. Assessment of spawning habitat needed as well as consideration for in river improvements for refuge. The main river is not preferred habitat for trout and so is not deemed as an essential area for works. However, any riparian works including tree hinging will offer refuge for all life stages of trout while migrating up or downstream and given the lack of refuge in some reaches, this action is recommended. The AFA commissioned the Wild Trout Trust to undertake a walkover of beats in 2011 and recommendations for habitat improvements can be referenced in the report and an investigation into access improvements for the Torr Brook are recommended in the Avon and Erme Salmon Action Plan (EA, 2003) as access by migrating salmonids to feeding and spawning grounds is being impeded by a large culvert.

The DRA maps in figure 9 below must be treated with some caution at this stage as there is limited catchment wide data for both salmon and trout. What they do allow however is a brief insight into the current state of juvenile salmonid recruitment with the available data at a glance and potential areas for improvement in each waterbody.



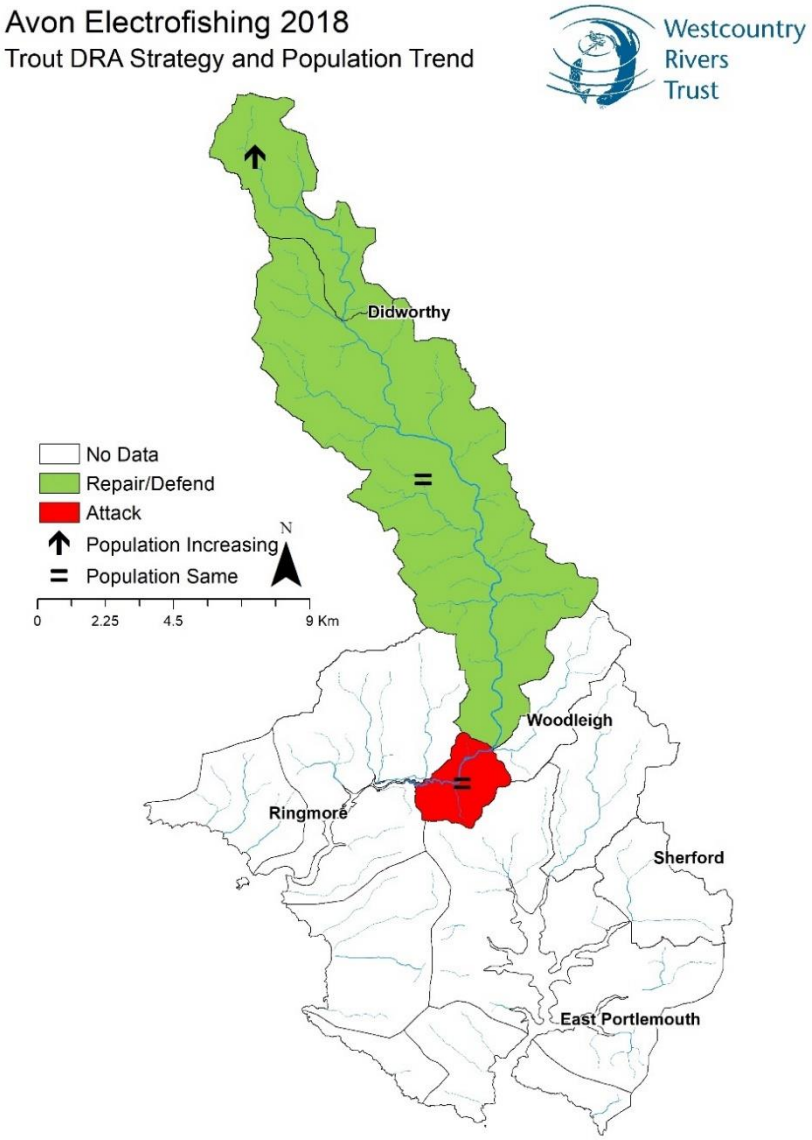


Figure 11 Salmon and trout DRA strategy and population trend

The surveys undertaken in the upper Avon in 2018 highlight the variability of annual results with regards to environmental factors, location of deposition of augmented gravels and their period of stability. There is an upward trend for salmonid numbers over the 6 continuously surveyed sites since 2013 which highlights the importance of ongoing monitoring beyond the 2020 gravel augmentation project end date. This includes monitoring gravel transportation throughout the reach as juvenile habitat improvement may increase/decrease over time. Continued electrofishing surveys will help to determine any impact upon salmonid recruitment and the lifespan of improved spawning habitat once augmentation ends. To date the 6 sites that have been surveyed for the longest time period have seen improvements in juvenile numbers post-augmentation.

Results in the lower Avon were disappointing but with no habitat improvements taking place it is not expected that results will change in the short term. To this end, it is suggested that the number of survey sites are increased to improve information on a catchment scale or WRT liaise further with the AFA to discuss potential relocation of these sites to areas where in-river works can be more easily undertaken. A suitable monitoring program running alongside these works to measure change is strongly recommended.

6. Acknowledgments

Many thanks to the landowners who gave permission to survey on their property and to the Avon Fishing Association for their continued support with annual surveys.

Thanks also go to South West Water for continued funding for the gravel augmentation project and subsequent biological monitoring associated with the project.

Thanks also go to Dan Griffiths at the Environment Agency for comments and feedback.