2015 Dee Stock Assessment

March 2016

Executive summary

This report provides an assessment of juvenile salmon stocks in the Dee in 2015. Despite the low number of returning adults in the last three years, which is part of a wider trend driven by poor marine survival, we conclude that there is still reasonable juvenile production in the Dee. This conclusion is made following a comparison of fish densities in the Dee in 2015 to mean national densities for a given habitat in a good year. Based on available electrofishing data, and assuming that the electrofishing sites were representative of the catchment as a whole, salmon fry densities in 2015 were broadly as expected and thus in reasonable health.

We would expect approximately 50% of sites to exceed their benchmark salmon fry densities if the catchment as a whole was in good health. Our surveys showed that this was achieved, as out of the 12 tributaries surveyed, seven (58%) exceeded the benchmark fry densities in 2015 at the majority of sites within the tributaries.

Evidence from rod catches and redd counts showed that 2011 was a year of high adult returns to the Dee, and thus spawner numbers should not be limiting fry numbers in 2012. Fry densities were found to be greater in 2012 than in 2015 in the upper Dee, and although this is based on a different set of electrofishing sites, this suggests that a reduction in adult spawners in 2014 may have affected subsequent juvenile production.

Fry production was also examined at sub-catchment levels and indicated that the Clunie, Girnock, Tarland and Beltie tributaries are performing less well than expected. In the case of the upper Dee sub-catchments this is likely to be due to low spawner abundance in 2014, leading to patchy fry distribution, whilst in the lower catchment this is likely due to poor habitat.

Simultaneously, there has been a national programme to develop Conservation Limits (the stock size required to support a maximum harvest) against which adult returns are compared. This work concluded that adult salmon stocks on the Dee in 2010-2014 were healthy. Taken together, these two approaches to assess Dee salmon stocks allow us to undertake fisheries management based on the best information available.

Background

The international picture for salmon stocks is concerning: The North Atlantic Salmon Conservation Organization (NASCO) reports that the Southern European (which includes the UK) grilse stock has either been at risk of or has failed to achieve the Conservation Limit most years since the 1970s, meaning that it is in danger of being unsustainable in the longer-term. The multi sea winter (MSW) stock has been at risk of or failed to achieve its Conservation Limit every year since 1996. These assessments are based on there being the required number of adults to maximise the long-term average surplus (Maximum Sustainable Yield) and are calculated before fishery catches are deducted.

At a national level, the decline in survival at sea since the 1960s is thought to have been largely compensated for by a decline in coastal and estuarine netting, therefore there has been an overall increase in adult salmon returning to Scottish rivers. However, since 2010 there has been a more widespread decline, as evidenced by rod catches (Marine Scotland Science 2015). Additionally, there is a difference between spring and summer/autumn stocks, with the number of spring salmon entering rivers generally having declined since the 1960s.

As part of measures to protect salmon stocks nationally, Scottish Government have requested an assessment on Scottish salmon stocks to determine if there should be any exploitation allowed by the rod fishery on each river, from 2016. This falls under the 'Licence to kill' legislation, which has also banned netting of salmon, outside of river estuaries. To deliver this, Marine Scotland Science (MSS) have calculated Conservation Limits for all Scottish fishery districts in 2015: The rod catch in each of the last five years was used to estimate total number of adult returns and from this an estimate of egg production was made, to determine if the number of returning adults in each year would produce sufficient eggs to fill each river. The Dee, along with many large East Coast Rivers, exceeded its Conservation Limit.

As MSS trap data indicate a close relationship between the number of female spawners returning to the Girnock and Baddoch tributaries in the upper Dee, and Spring rod catches, it is a reasonable assumption that rod catches reflect returning adult numbers and can provide a picture of the health of the Dee salmon stock (Figure 1).

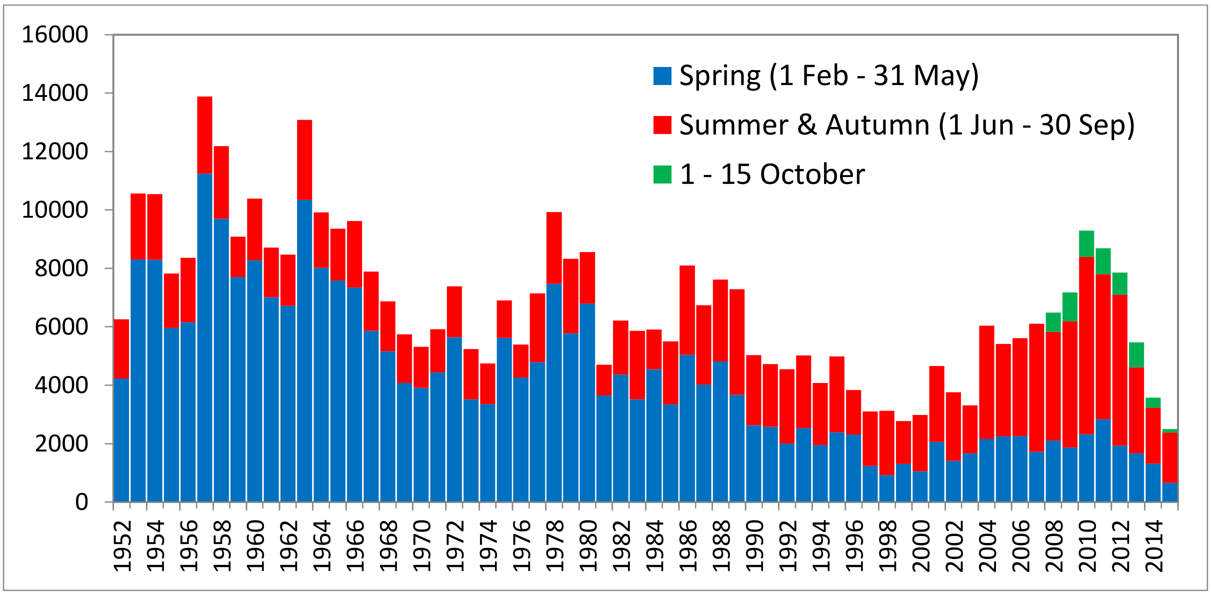

Figure 1. Salmon rod catches for the River Dee, 1952 – 2015 (MSS data).

Following a decline in rod catches between the 1960s and 1990s, total catches improved for ten years, whilst spring rod catches remained stable for these ten years. However, following a peak in 2010, total rod catches have declined in each year and in 2015 were the lowest recorded since records began, 63 years ago.

The estimation of CLs for salmon in Scottish rivers required various assumptions, given a paucity of available data. These CLs will be improved over time as more data becomes available and assumptions can be refined. However, in the meantime, there are additional forms of stock assessment available for the Dee, owing to the monitoring and research that has previously been done by the Board and Trust and MSS.

Following a review of options in 2015, the chosen method for stock assessment that has been applied is based on a comparison of observed juvenile fish abundances to a mean national expectation using an approach developed by MSS (Millar et al., 2015). Thus our approach focuses on juvenile stocks whilst the national Conservation Limits assesses adult stocks, so together they provide a fuller picture for the Dee. Neither approaches are perfect though and so both will see future iterations to refine these assessments.

Aims

As set out in the Dee Fisheries Management Plan, we are developing a form of assessment to estimate salmon stock health in the short- and medium-term. This can be simplified by asking two questions:

1. How many salmon do we have in the Dee
2. How does this compare to how many salmon we need

We answer the first question in this report based on juvenile fish stocks in 2015. In a second short report (River Dee Trust 2016) we explore the second question, although it should be noted that the data and underlying assumptions of the approach provide for a weak level of accuracy at present.

Methods

Electrofishing

Juvenile salmon (fry and parr) densities were obtained from electrofishing surveys carried out in the summer of 2015. These included 48 semi-quantitative (1-sweep) and 29 fully-quantitative (3-sweep) surveys to enable calibration of capture probabilities. 32 of these sites form the ‘catchment health monitoring’ programme, which provides an overview of the Dee catchment. Of these sites, 17 are in the upper Dee and 15 are in the middle and lower Dee. The middle and lower Dee sites were surveyed for the first time in 2015 and will be repeated annually. Additionally, 34 electrofishing sites that were surveyed in 2015 for other purposes were also included in the 2015 assessment (although note that these are not necessarily surveyed every year). An additional 11 sites surveyed by Marine Scotland Science on the Girnock and Baddoch burns were also included in the analysis.

These 77 sites were characterised by a range of environmental characteristics: 9 – 127 km from the sea, 15 - 521 m altitude, 1 - 25 m channel width, 0 – 14˚ gradient, catchment size of 1 - 86 km^2 and land uses ranging from moorland to woodland, arable and grassland. These factors are shown by Millar et al. (2015) to affect fry densities, with the greatest impact on fry densities caused by:

1. Distance to sea (higher densities are predicted for greater distances to sea, up to ca. 100km);
2. Upstream catchment area (lower densities predicted for particularly small and large areas);
3. Altitude (densities predicted to decline with increasing altitude).

The effect of land use was specifically that fry densities were negatively related to increasing urban and conifer land uses.

Habitat factors that influence juvenile salmon density at a more local level were also recorded in the field at the time of sampling and although these were not included formally in the analysis, assisted interpretation of the findings. Field recorded characteristics included percentages of different river bed substrate, dominant flow type, presence of siltation, and an overall visual assessment of instream cover for juvenile salmonids (poor - excellent).

Data analysis

Salmon fry abundances at each site in 2015 were calculated by MSS from the numbers of fish caught by electrofishing, using the capture-probability model developed by Millar et al (2015).

A benchmark density was calculated for each of the 77 electrofished sites, based on the national fry density model developed by Millar et al. (2015) for comparison with the observed 2015 fry densities. The national fry density model was underpinned by data collected by MSS, SEPA, Fisheries Trusts and Boards for a variety of purposes. In total, it consisted of 3743 electrofishing observations from 1875 sites, surveyed between 1997 and 2013.

The benchmark fry densities for the 77 Dee sites were calculated for the year with the highest mean national fry density, incorporating the effect of the habitat characteristics and excluding anthropogenic impacts of coniferous forestry and urban area. As such the benchmark equates to a standardised level that can be used to compare across time and space. To be an unbiased benchmark of a carrying capacity in which each river is fully stocked with eggs, this national dataset would need to be representative of all available habitats in Scotland, include years where adult numbers were sufficient to fully stock the rivers and exclude any sites affected by anthropogenic impacts that were not accounted for in the model, as described above. However, the dataset could contain biases towards high- or low-density sites, for example, there could be biases if the data incorporated into the national survey if in some areas or at certain times local surveys had focused on areas that were failing to perform/over-performing. Further negative bias could be introduced if there were no years with sufficient adult returns from all stock components to fully stock available habitat, or if particular regions received unusually low returns.

Unfortunately at this stage it is impossible to determine how or where such biases exist. Under such circumstances, model predictions have been made from the best available data. Where “pressures” could be identified e.g. urban land use or conifer forest (largely expected to be plantation forestry), estimates of these effects have been made such that their influence is excluded. In addition, locations which were known to be affected by impacts such as impassable barriers or stocking were filtered from the dataset prior to modelling. As such, the benchmark densities can be considered the best available mean national benchmark densities for a given habitat, in a good year. The values are useful for identifying whether fish densities are likely to be below potential fry production. However, low local densities may be due to a number of factors, including low numbers of spawners, distance to a redd that exceeds dispersal capacities of fry and poor local habitat quality. Hence, the approach can provide a good indicator of general health provided that suitable interpretation is applied.

Spawner abundance

Redd count surveys are carried out each year and are useful for showing years of low and high spawner abundance (reviewed in River Dee Trust, 2015). However, consistent counting of the same sites each year has only been carried out since 2006, and mostly since 2011, when the current annual monitoring programme began (Table 1). A total of 12 tributary sites have been monitored regularly, of which most sites (nine) showed highest spawner abundance in 2011 (Table 1; River Dee Trust, 2015). This also concurs with a high rod catch and high adult returns to the Baddoch fish trap (although not the Girnock trap) in 2011. This would therefore be associated with high fry production in 2012. As an aid to interpreting the 2015 stock assessment, fry densities in 2012 have also been analysed, for the available electrofishing data.

Table 1. Redd count tributaries surveyed regularly (up to 2014).

Location	Years monitored	No of years monitored	Best year (maximum number of redds)	Corresponding year for fry
Bynack	2011 - 2014	4	2011	2012
Upper Dee	2011 - 2014	4	2011	2012
Ey	2006 - 2007 & 2012- 2014	5	2013	2014
Clunie	2009 - 2014	6	2009 & 2013	2010 & 2014
Ballochbuie	2011 - 2014	4	2011 & 2013	2012 & 2014
Gairn	2011 - 2014	4	2011	2012
Feardar	2009 - 2014	6	2011	2012
Drum	2009, 2011 - 2014	5	2011	2012
Sheeoch	2007, 2009 - 2014	7	2012	2013
Beltie	2008 - 2014	7	2011	2012
Tanar	2010 - 2014	5	2011 & 2013	2012 & 2014
Quithel	2010 - 2014	5	2011	2012

Results

2015 assessment

Salmon fry densities in 2015

Salmon fry densities were estimated from 2015 electrofishing data using the national salmon catch probability model (Millar et al 2015). Fry densities ranged from 0-1.2 fry per square metre (m^{-2}) in 2015, with a mean of 0.2 fry m^{-2}. There was a high level of variability in the fry densities within the catchment (Figure 3), even between sites that were located close together.

Assessing the stock health at electrofishing sites

The fry densities in 2015 can be assessed by comparing them to the benchmark densities (the mean density from the national model in a good year). The benchmark fry densities throughout the catchment are shown in Figure 4. This shows that fry production is predicted to be greatest in the main stems of some of the larger tributaries in the upper Dee and the majority of tributaries in the lower Dee. Overall, greater fry production is expected from the lower catchment. Figure 4 also highlights where there is insufficient information to make reliable predictions (predominantly on the main stem).

If the 2015 fry data for the River Dee was to meet national expectation (the benchmark) then it would be expected that approximately half of all the sites would exceed their benchmark and half would fall below the benchmark, assuming that the sample was representative of the catchment as a whole and that the distribution of passing and failing sites was random. However, the distribution of sites is not random as some tributaries have more sites than others (particularly the upper Dee sites). Therefore an assessment was made based on the proportion of sites within each tributary that exceeded their benchmark. Additionally, the nine sites on the Culter catchment (which has only been accessible to salmon since 2014 when a fish pass was fitted to the Culter dam) and two sites at the top of the Sheeoch (above an impassable waterfall) were excluded (as highlighted in Figure 3).

Overall, the fry densities in 2015 were broadly as expected from the benchmark densities (Figure 4). Seven of the 12 tributaries (58%) exceed expectations based on national fry densities and four sites (33%) fall below expectation, and a further one site is at expectation (equal number of sites within the tributary above and below their benchmarks).

The tributaries found to be underperforming in 2015 compared to their benchmark were the Clunie, Feugh, Tarland and Beltie burns.

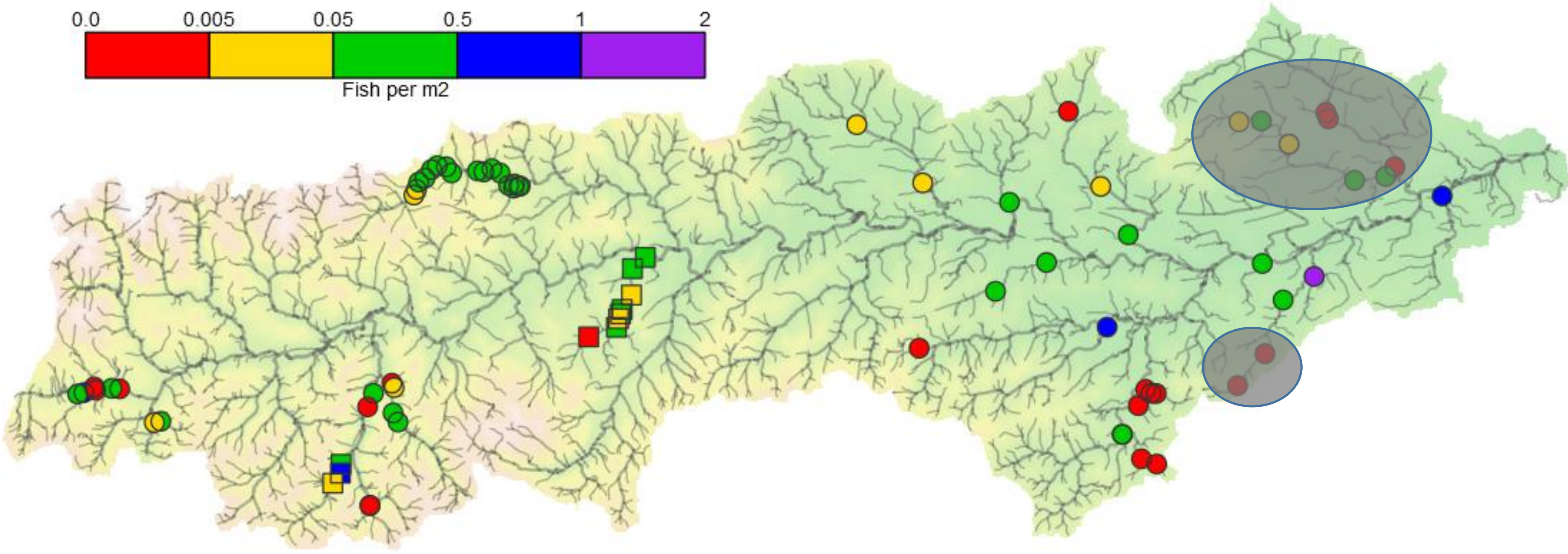

Figure 3. Salmon fry densities on the River Dee in 2015. Densities have been estimated from electrofishing data collected by the River Dee Trust (circles) and Marine Scotland Science Freshwater Fisheries Laboratory (squares) using the national salmon fry capture probability model (Millar et al 2015). Sites covered by grey circles have no or only recent accessibility to salmon (Culter burn and Sheeoch burn).

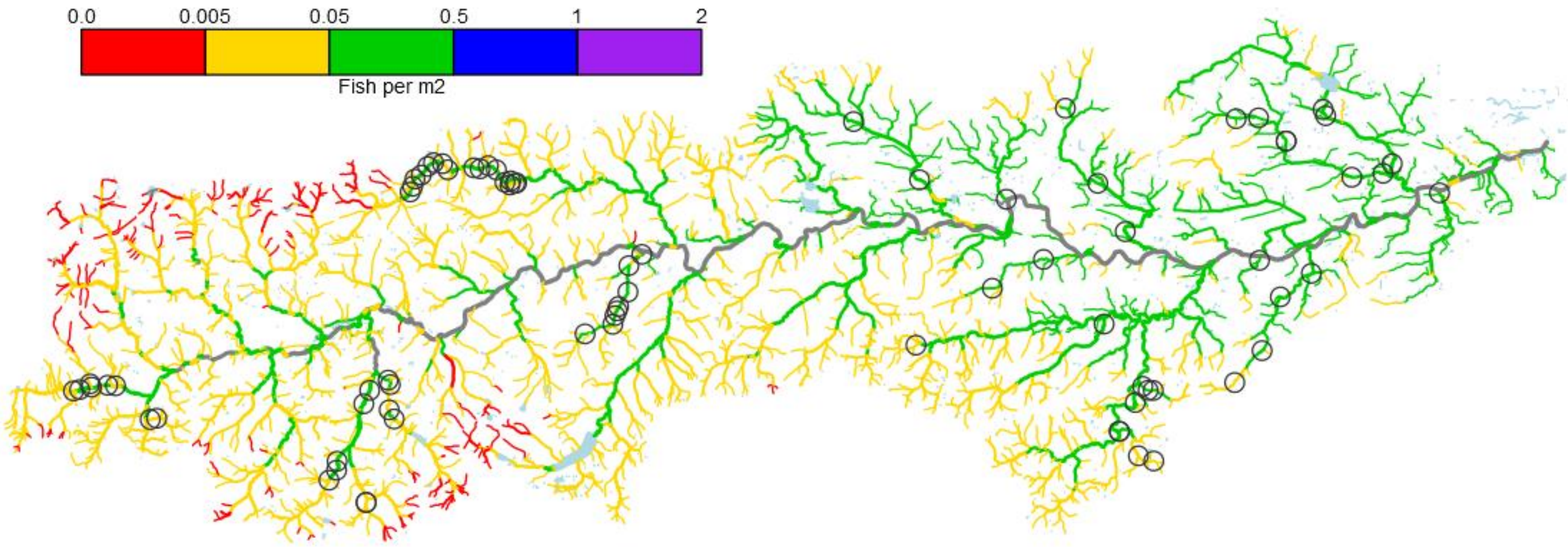

Figure 4. Benchmark salmon fry densities in the River Dee. Densities are based on the national salmon fry density model described by Millar et al. (2015) and represent an average national expectation for the year with the highest national average fry abundance (2006) observed between 1997 and 2013. To avoid extrapolation beyond the data range available to Millar et al (2015) no predictions are made for the grey (rivers) or light blue (lochs) areas. Predictions do not consider the effects of barriers to fish passage. Black circles indicate electrofishing sites.

Further analysis shows by what level these sites fail to meet or exceed their benchmark (Figure 5), by looking at the difference between the 2015 fry densities and the benchmark densities. This shows that some tributaries on the upper Dee well exceeded the benchmark in 2015, e.g. Gairn (as indicated by the high proportion of positive sites), while others such as the Clunie and Girnock often fell short of their benchmark (greater proportion of lower performing sites). In the middle and lower Dee catchment, sites on tributaries close to the main stem appeared to perform better than expected, while higher altitude sites often performed less well than expected e.g. the Water of Dye on the Feugh tributary.

The absolute differences between 2015 fry densities and benchmark densities indicates how much production is being gained or lost (Figure 6) in terms of fish production per square metre. The most substantial reductions in fry production would occur at sites that performed less well than expected (as shown in Figure 5), in parts of the catchment where production was expected to be high (as shown in Figure 4). This included lower Dee tributaries (such as the Tarland and Beltie burns) and moderate-altitude sites in the upper catchment (such as the Girnock burn and lower Clunie).

Comparison to year of high spawner abundance

Redd count data, rod catches and adult returns to the Baddoch trap (although not the Girnock trap) all indicated that 2011 was a year of high spawner abundance, relative to recent years. Therefore we expect the highest fry production in recent years to have occurred in 2012. The fry densities in 2012 are shown in Figure 7. The catchment health monitoring programme had not begun in 2012 and therefore we have made use of all available data, which is sufficient for assessing the upper Dee. However, the lower Dee survey sites are largely relating to monitoring recolonisation of the Coy burn (following installation of a fish pass in 2008), high-altitude tributaries of the Feugh and two sites above an impassable waterfall on the Sheeoch. Therefore a comparison of fry densities between 2012 and 2015 is possible for the upper Dee only.

There was higher fry densities in 2012 than in 2015 – all six of the upper Dee tributaries (100%) exceeded their benchmark in 2012, compared to two out of four upper Dee tributaries (50%) in 2015.

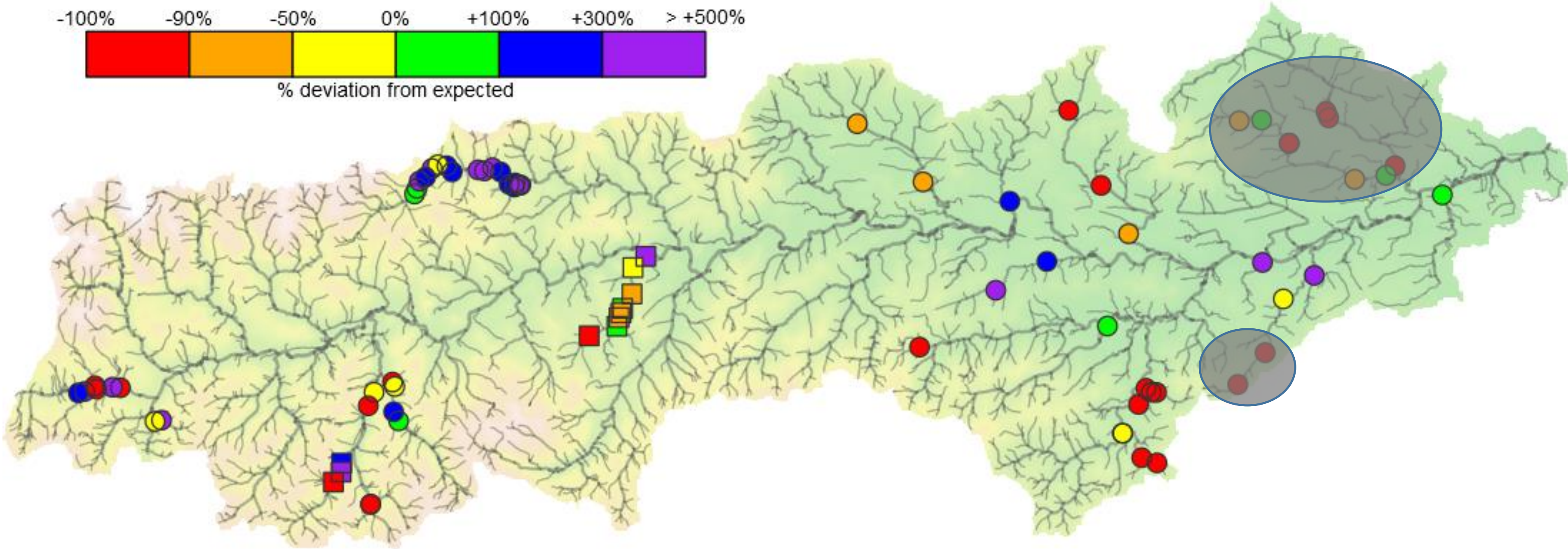

Figure 5. Percentage differences between 2015 salmon fry densities and benchmark densities in the River Dee. Positive values indicate that sites have done better than expected. Sites covered by grey circles have no or only recent accessibility to salmon (Culter burn and Sheeoch burn).

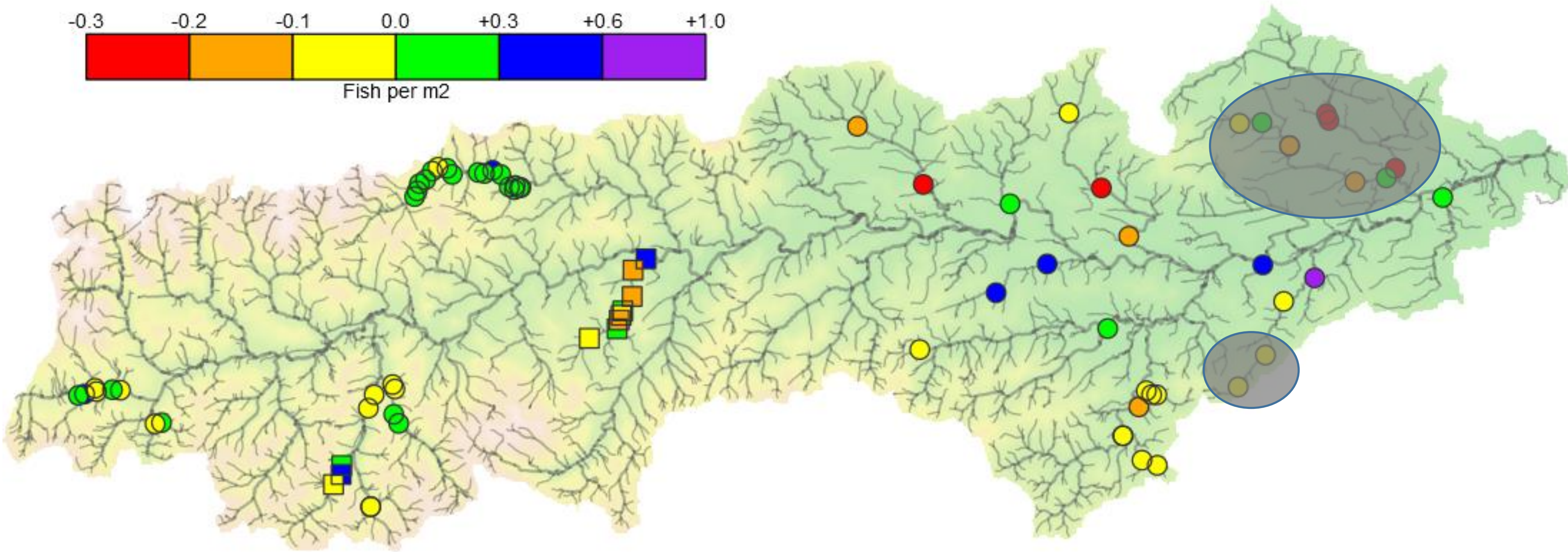

Figure 6. Absolute differences between observed and benchmark salmon fry densities in the River Dee in 2015. Positive values indicate that sites have done better than expected. Sites covered by grey circles have no or only recent accessibility to salmon (Culter burn and Sheeoch burn).

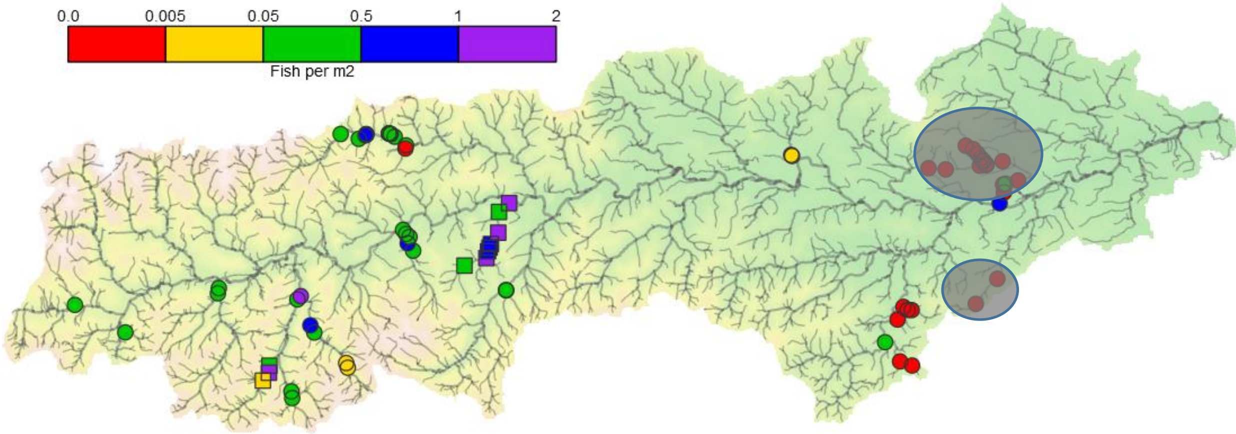

Figure 7. Salmon fry densities on the River Dee in 2012. Densities have been estimated from electrofishing data collected by the River Dee Trust (circles) and Marine Scotland Science Freshwater Fisheries Laboratory (squares) using the national salmon fry capture probability model (Millar et al 2015). Sites covered by grey circles have no or only recent accessibility to salmon (Coy burn and Sheeoch burn).

Conclusions

2015 stock assessment

The overall assessment is that the Dee has had reasonable salmon fry production in 2015, resulting from the 2014 adult spawners. Fry densities exceeded their benchmark in seven out of 12 tributaries, and we would expect approximately 50% exceedance of the benchmark if the catchment as a whole was in good health. This conclusion is based on a juvenile stock assessment that compares 2015 fry abundance in the Dee with national average salmon fry densities and incorporates variations in certain habitat and anthropogenic influences. In effect, this approach allowed a benchmark fry density to be estimated for each site, reflecting ideal and pristine conditions because factors that limit fry abundance were excluded.

However, there has been a decline in juvenile production compared to 2012, when all upper Dee tributaries surveyed exceeded their benchmark. Redd count surveys highlighted that 2011 was a good spawning year (with a rod catch of 8,686) and therefore expectations were for high fry production in 2012, as was found to be the case. In contrast, there was lower spawner abundance in 2014, as indicated by a lower rod catch of 3,570 and less spawning detected in redd count surveys.

The assessment is only as good as the data that underpins it and caveats have been highlighted that could affect the absolute level of the benchmark densities, against which our assessment is made. The main caveat is that the benchmark densities do not necessarily equal the carrying capacity of these Dee sites, because if any of the rivers included in the national dataset did not reach capacity during the period 1997 to 2013 the effect would be to reduce the mean national fry density, and hence the benchmark for the Dee sites. However, there are flaws in all methods of stock assessment and the benchmark densities for juvenile fish are the best national data available. The study by Millar et al (2015) showed there is strong coherence in fry densities at a national scale, suggesting that the national data used in this assessment reflects genuine good/bad years for fish production.

Catchment issues

A benefit of the fry assessment approach used here (compared to the catchment-level approach carried out for national assessments) is that it includes variability in fry production within the catchment, which can highlight differences in fish production in different areas. It was clear that fry production varies across the Dee, although this is largely as predicted based on habitat characteristics of the sites: The expectation was for good production at low altitude in the lower catchment tributaries and low production at high altitude sites in the lower Dee. There was also an expectation for higher production in the main stems of upper Dee tributaries.

Areas containing a large proportion of sites with lower than expected fry densities warrant further investigation. Such areas included the River Clunie, Girnock, Tarland and Beltie burns and tributaries of the River Feugh. Such observations could arise from low spawner numbers that generate patchy spawning or from poor quality habitat. We suggest that low spawners may explain the fry densities in the Girnock and probably also in the Clunie, as these sites all performed a lot better in 2012. However, sites on the Feugh tributaries were equally poor in 2012 and this may instead reflect locally poor habitat that was not factored into the model. Poor habitat is also thought to explain the under-production in the Tarland and Beltie burns.

The maps produced in this report provide an indication of the most important areas for salmon fry. Such information could be used to prioritise protection or restoration measures. Prioritising sites should focus on low-altitude sites that underperform, as these areas suffer a greater loss of production compared to high-altitude sites (which are expected to have low fry production anyway). Thus the important sites highlighted are the Tarland burn and the upper and middle sections of the Beltie burn.

Conservation Limits

Conservation Limits (CLs) have been developed by MSS at a national level for the first time in 2015. These CLs use rod catches in 2010 - 2014 to estimate numbers of adult salmon returning to the Dee, then estimate how many eggs they will produce and compare this to how many eggs are required to fill all the habitat in the Dee. Notwithstanding the caveats in the national assessment (including that the calculations estimate various figures from other rivers which may not be true for the Dee), this assessment determines that the Dee has exceeded its CL in each year 2010 – 2014. In short, when considered at a whole-river scale, there has been enough fish returning to meet the conservation limit.

The national approach focuses on adult stock size to come to this conclusion. The approach we have taken here, which is complimentary in that it focuses on juvenile stocks, comes to broadly the same conclusion. In particular, 2014 was a year of low rod catches, which indicates low adult returns (as shown by the Baddoch and Girnock fish traps), but based on the national assessment that the adult stocks met the Conservation Limit, it was expected that sufficient eggs to restock the river with fry were produced in 2015. Our results also show that fry densities in 2015 were reasonable overall (although variable through the catchment) and above the national average (for 1997 – 2013), despite being lower than previous 'good' years.

Technical developments

In terms of the data collected to undertake this assessment, there will be a few additional sites surveyed in future to represent mid-altitude sites, as part of the catchment health monitoring programme. For example, the Tanar and Muick tributaries will be included.

At a national level, there will need to be some development of methods to assess juvenile stocks in the main stems of rivers, where quantitative electrofishing is not possible. At present we have no accurate method for estimating fish densities in the main stem.

The national adult Conservation Limit assessment will also be developed in future years. The Board and Trust will facilitate this by providing additional data to help refine the calculations for the Dee. The national fish counter network that is currently being developed by MSS will also provide more information on exploitation rates and so help improve adult stock size estimates. This will involve a few rivers in Scotland, chosen to represent the other Scottish rivers. To fully benefit the Dee, it is important that we encourage this proposed network to include the Dee as one of the sites.

Where do we go now

This is the first attempt at assessing salmon stock health for the Dee catchment. Two assessments have been done this year; the first by us with a focus on juvenile stocks, and the second by MSS with a focus on adult stocks. It is essential that our management system is based on the best information we have, and this report brings together the best information that is currently available. However, both assessments are first iterations of models that will be refined in subsequent years in response to improved information and assessment techniques.

The value of this stock information is that it allows us to demonstrate any deterioration in our salmon stocks, not based on anecdotal evidence. This is required for management of the fishery in local terms and also in terms of protecting a nationally and internationally important fish stock, and to be able to demonstrate where further measures and resources are required to deliver this.

At a local level, this juvenile stock assessment has highlighted key areas of the catchment that are (1) particularly important for fish stocks and (2) particularly underperforming and require attention. Alongside the habitat survey information collected over the last two years that has not been presented here, this will be used to build a programme of work for the freshwater environment. This level of focus is essential for it to be delivered alongside the work that we are now developing in the marine environment.

Acknowledgements

We thank Marine Scotland Science Freshwater Fisheries Laboratory for assistance in the analysis and interpretation of data for the stock assessment. In particular, we thank Iain Malcolm and Colin Millar for providing data and undertaking the modelling of fish densities. We thank Stuart Middlemass for providing information about the national Conservation Limit assessment.

References

Carle FL & MR Strub (1978). A new method for estimating population size from removal data. *Biometrics*, **34**, 621-830.

Gurney WSC, Bacon PJ, McKenzie E, McGinnity P, McLean JC, Smith GW & AF Youngson (2010). Form and uncertainty in stock-recruitment relations: observations and implications for Atlantic salmon management. *Canadian Journal of Fisheries and Aquatic Sciences* **67**, 1040-1055.

Hendry K & D Cragg-Hine (1997). Restoration of Riverine Salmon Habitats. A Guidance Manual. Fisheries Technical Manual 4, R&D Technical Report W44. Environment Agency.

Marine Scotland Science (2015). Salmon Fishery Statistics – 2014 Season. Topic Sheet No. 68. Crown Copyright Marine Scotland.

Marine Scotland Science (2010). Marine mortality rate in Atlantic salmon. Topic Sheet No. 40. Crown Copyright Marine Scotland.

Millar CP, Millidine KJ, Middlemas SJ & IA Malcolm (2015). Development of a model for predicting large scale spatio-temporal variability in juvenile fish abundance from electrofishing data. Scottish Marine and Freshwater Science Report. No. 6. Crown Copyright Marine Scotland Science.

Mills D & D Piggins (1988). Atlantic salmon: Planning for the Future. (Eds). The Proceedings of the Third International Atlantic Salmon Symposium. Croom Helm Ltd, London & Sydney.

Milner NJ, Wyatt RJ & MD Scott (1993). Variability in the distribution and abundance of stream salmonids and the associated use of habitat models. *Journal of Fish Biology* **43 (Suppl. A),** 103-119.

River Dee Trust (2015). Redd counting surveys on the Dee.

River Dee Trust (2016). Stock requirements for the Dee catchment 2015.