WATER RESOURCES ACT 1991

THE WALES ROD AND LINE (SALMON AND SEA TROUT) BYELAWS 2017

THE WALES NET FISHING (SALMON AND SEA TROUT) BYELAWS 2017

DOCUMENT NRW/3

PROOF OF EVIDENCE

OF

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on behalf of

CEFAS and NATURAL RESOURCES WALES

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1 Personal background

1.1 My name is Jonathan Barry. I have a BSc in statistics from Reading University, an MSc in statistics from Edinburgh University and a Ph.D. in statistics from Lancaster University. I was originally employed as a statistician at Cefas from 1985 to 1987 and have been working for Cefas continuously since 2001. In the intervening years I was employed as a researcher and lecturer in the Department of Mathematics and Statistics at Lancaster University. Since 2017 I have been appointed as an honorary lecturer in the Environment section of the Data Science Institute at Lancaster.

1.2 I have carried out statistical consultancy for over 30 years, since 1986. I have currently published around 85 peer-reviewed papers in the academic literature. Most of my work is in the ecological and environmental sciences.

1.3 Cefas is the Centre for Environment, Fisheries and Aquaculture Science. Cefas is a world leader in marine science and technology providing innovative solutions for the aquatic environment, biodiversity and food security.

2 Scope of evidence

2.1 In this statement, I set out my involvement with the review of Natural Resources Wales (**NRW**)'s Technical Case and the resulting exchanges by correspondence between stakeholder groups and Welsh Government arising from the formal consultation process.

2.2 The scope of my evidence addresses the underlying statistical methodology by which NRW have identified that there is a problem, and determined its nature and extent.

2.3 Capitalised terms used in this proof of evidence that are not defined in the proof are defined in the Glossary appended to the proof of Mr Gough[1].

[1] NRW/1(D).

3 Involvement in the All Wales Byelaws

3.1 I had no involvement in the initial review of the NRW technical case; this is covered in paragraphs 1.5 and 1.6 of the evidence provided by Mr Ian Russell, my colleague at Cefas[2]. My involvement in this process stemmed from correspondence between various stakeholder interests and Defra in relation to measures being developed in England; concurrent with the measures being developed in Wales.

3.2 Specifically, I was asked to provide expert advice on the statistical elements underpinning the approach for assessing the status of salmon stocks (N.B. this is common to both Wales and England) and the associated procedure for assessing compliance with the over-arching management objective. This request had arisen as a result of the reports prepared by Dr Adrian O'Hagan and Dr Michael Fop[3], which contained a statistical critique of current procedures[4]. My advice was originally aimed at assisting Defra in responding to Ministerial correspondence in relation to the various points raised by O'Hagan and Fop.

3.3 Since similar communications had also taken place between the same stakeholder groups and Welsh Ministers, a formal Cefas response was prepared, based on my advice, and following consultation with colleagues at NRW and the Environment Agency. This response was then shared with Defra and Welsh Government and appended to responses to stakeholders.

[2] NRW/4.
[3] At Appendix 1 to my proof.
[4] See paragraph 5.1 below.

4 Statistical basis of salmon stock assessment modelling

4.1 The use of conservation limits in England and Wales has developed in line with the requirement of ICES and NASCO to set criteria against which to give advice on stock status and the need to manage and conserve individual river stocks. The status of individual river stocks in Wales is evaluated annually against these criteria. Conservation limits indicate the minimum desirable spawning stock levels below which stocks should not be allowed to fall. The Conservation Limit is set at a stock size (defined in terms of eggs deposited) below which further reductions in spawner numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation.

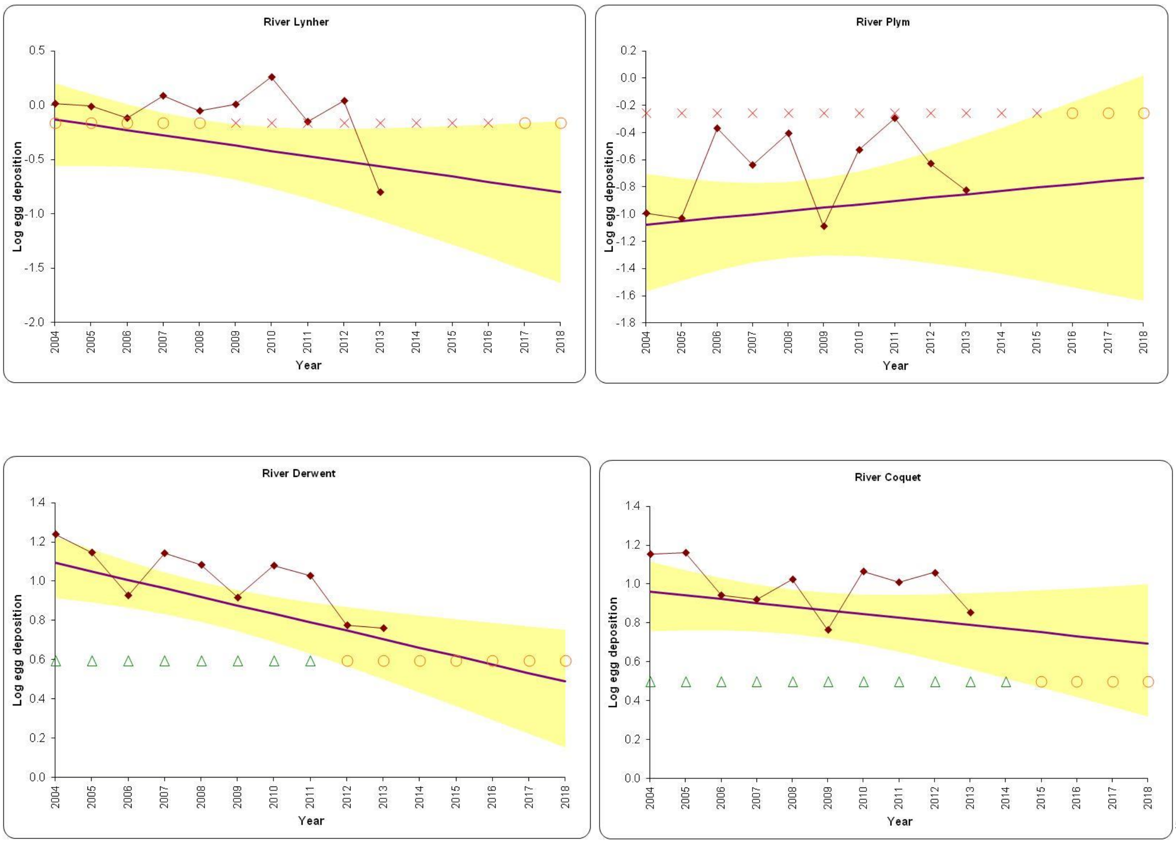
4.2 Annual compliance with the Conservation Limit is assessed using egg deposition estimates. These are derived from returning stock estimates, where such data are available, but for rivers without traps or counters, the usual procedure for estimating egg deposition involves derivation of run size from rod catch using estimates of exploitation (and an appropriate adjustment for under reporting). Currently, these procedures do not take into account annual changes in fishing effort.

4.3 In reviewing management options and regulations, NRW (and the Environment Agency in England) also use an over-arching management objective that a river's stock should be meeting or exceeding its conservation limit in at least four years out of five (i.e. >80% of the time). A management target is set for each river, representing a spawning stock level for managers to aim at in order to meet this objective. Compliance with this objective is calculated annually for all the principal river stocks in Wales (and England) for the latest assessment year and forecast for five years ahead. These assessments for each Principal Salmon River are then incorporated into a national decision structure for guiding decisions on the need for fishery regulations.

4.4 A decision structure for determining fishing controls on salmon fisheries in England and Wales has been developed to assist in applying fisheries regulations in a logical and consistent manner, and in line with NASCO guidance. This tool focuses on an assessment of the probability of achieving the management objective in five years' time for a given river's salmon stock. It indicates the level of change in exploitation rate required in order to improve failing rivers, and helps to highlight the need for other management actions where these may be appropriate. The decision structure is applied annually as part of a regular review process when the stock assessment for the fisheries in England and Wales is published.

4.5 **Details of the annual compliance assessment** - The performance of salmon stocks in Wales (and England) is assessed using a compliance scheme designed to give an early warning that a river has fallen below its conservation limit. An approach introduced in 2004 provides a way of summarising the performance of a river's salmon stock over the last 10 years (including the current year), in relation to its conservation limit. Bayesian regression analyses are applied to egg deposition estimates from the last 10 years, on the assumption that there might be an underlying trend over the period for changes in egg numbers to be proportionate to the egg numbers themselves (so that the rate of change is higher when there are many eggs, and the rate of change is lower when there are fewer eggs). Such a trend would appear as a linear trend in the logarithms of the egg numbers, as shown on the plots at 4.6 below. The method fits a 20-percentile regression line to the data and calculates the probability that this regression line is above the conservation limit, and thus that the conservation limit will be exceeded four years out of five (the management objective). If there is a low probability (< 5%) that the predicted line is above the conservation limit, the river fails to comply (i.e. is regarded 'at risk'). If the probability is high (> 95%), the river complies in that year (i.e. is 'not at risk'), whereas between these probability values we cannot be certain of the stock status (the river is assessed as either 'probably at risk' (5% < p < 50%) or 'probably not at risk' (50% ≤ p < 95%)). The current scheme also allows the 20-percentile regression line to be extrapolated beyond the current year in order to project the likely future performance of the stock relative to its conservation limit, and so assess the likely effect of recent management intervention and the need for additional measures.

4.6 The compliance plots for the Rivers Lynher, Plym, Derwent and Coquet for the years 2004-2013 are shown below as examples (these are English rivers, but are used for illustration purposes – the same criteria apply in Wales). These include individual egg deposition estimates (black dots on the graphs) for these years, the 20 percentile regression lines and (shaded) 90% Bayesian Credible Intervals, and the conservation limit lines (represented by up to three symbols: X, O and Δ).



[5]

4.7 When the upper bound (95 percentile) of the regression line Bayesian Credible Interval is below the conservation limit line the river is judged to be failing its conservation limit (i.e. there is a ≥95% probability of failure or the river is ‘at risk’). For example, this is the case on the Lynher from 2009 to 2016 and the Plym from 2004 to 2015 and is indicated by the X symbol on the conservation limit line. When the lower bound (5 percentile) of the regression line Bayesian Credible Interval is above the conservation limit line the river is judged to be passing its conservation limit (i.e. there is a ≤5% probability of failure and the river is ‘not at risk’). This is the case on the Derwent from 2004 to 2011 and the Coquet from 2004 to 2014 and is indicated by the Δ symbol on the conservation limit line. For all other years on these rivers, the shaded Bayesian Credible Interval of the regression line overlaps the conservation limit line and so the status of the river is judged as ‘uncertain’ (i.e. the probability of failure is >5% but <95%, and the river is either ‘probably at risk’ or ‘probably not at risk’). This is the case on the Lynher from 2004 to 2008 and in 2017 to 2018, on the Derwent from 2012, the Coquet from 2015 and on the Plym from 2016 and is indicated by the O symbol on the conservation limit line.

[5] It should be noted that the Y axes on these figures are on logarithmic (Base 10), not linear, scales.

4.8 Egg deposition estimates for a river may be consistently above the conservation limit but status may still be uncertain. This is the case on the Coquet from 2015 and the Derwent from 2012 (O symbol on the conservation limit line). In part, this reflects the marked year-to-year variation in egg deposition estimates on these rivers, which produces broad Bayesian Credible Intervals around the regression lines, but also arises because of the slope of the trend line and the increasing uncertainty associated with all regressions once extrapolated beyond the data set.

4.9 As well as providing an assessment of the status of a river in relation to its conservation limit, the direction of the trend in the 10-year time-series of egg deposition estimates and its statistical significance may also serve as an important indicator of the need to take management action and of the degree of intervention required. Thus, a clear negative trend would give additional cause for concern.

4.10 The Management Target (**MT**) for each river is a spawning stock level for managers to aim at, to ensure that the objective of exceeding the Conservation Limit (**CL**) is met four years out of five in the long run (i.e. 80% of the time). The value of the management target has been estimated using the standard deviation (SD)[6] of egg deposition estimates for the last 10 years, where: MT = CL + 0.842*SD. The constant 0.842 is taken from probability tables for the standard normal distribution, such that the conservation limit forms the 20th percentile of a distribution, the average (or 50 percentile) of which equates to the management target. This means that if the river is reaching its Management Target, there should be an 80% chance of a given sample exceeding the Conservation Limit.

4.11 Conservation Limits and Management Targets form only one part of the assessment of the status of a stock, and management decisions are never based simply on a compliance result alone. Because stocks are naturally variable, the fact that a stock is currently exceeding its Conservation Limit does not mean that there will be no need for any management action. Similarly, the fact that a stock may fall below its Conservation Limit for a small proportion of the time may not mean there is a problem. The magnitude and duration of compliance failures are thus a key consideration. A range of other factors are also taken into account, particularly, the structure of the stock and any evidence concerning the status of particular stock components, such as tributary populations or age groups, based for example on patterns of run timing

[6] A measure of how much the values of the egg deposition estimates vary.

and the production of juveniles in the river sub-catchments. These data are provided by a programme of river catchment monitoring.

5 Discussions with University College, Dublin Academics

5.1 I was asked to review comments included in reports produced by Dr O'Hagan and Dr Fop that were appended to letters sent by stakeholder groups and received by both English and Welsh Ministers in response to the consultation process around the proposed new fishery control measures in both countries. Two reports were produced by Dr O'Hagan and Dr Fop:

5.1.1 'National River Classification Model – Report' and

5.1.2 'National River Classification Model – Qualified Statement'.

Both of these documents are appended to this statement[7].

5.2 I produced an initial assessment of the O'Hagan and Fop reports on this work in April 2018. This was used to inform the production of a formal Cefas response, which was developed in consultation with colleagues in the Environment Agency and NRW. I had sight of and approved the content of this response, which was later included in Defra's May 2018 response to the Chairman of the Ribble Fisheries Consultative Association, one of a number of stakeholder representatives that had entered into correspondence with Defra about the measures being proposed in England and Wales. I understand that the Cefas response was also shared with various other stakeholders, including those in Wales.

5.3 I therefore provided the expert statistical advice that underpinned the report titled: '*Response to the comments made by O'Hagan and Fop on the methods used to estimate compliance with the management objective for salmon stocks in England and Wales.*' (9 May 2018). A copy of this report is appended to this statement[8].

5.4 I later produced a further short report in response to a further request from Ian Russell. This followed the circulation of additional comments on statistical issues from Dr O'Hagan and Dr Fop that had been produced in response to the Cefas report. These comments were included in further correspondence sent to Defra by Mr John Rawlinson, dated 25 May 2018[9]. This work was done in August 2018, but was not developed into a further paper or used in subsequent responses from Defra.

[7] Appendix 1, NRW/3(B).
[8] Appendix 2, NRW/3(C).
[9] Appendix 3, NRW/3(D).

5.5 Essentially, I do not agree with O'Hagan and Fop on many of the more minor points that they raised. However, more importantly, I am at odds with them on their opposition to assuming a linear reduction in (log) egg numbers in the future when one has been observed in the past (they consider that there is no basis for assuming such a reduction).

5.6 The following is what I believe is the core of the dispute and is why I support the EA's, and NRW's, approach. This is a slightly edited version of material from my report of 23rd August[10].

5.7 The method used by the Environment Agency and NRW is based on a precautionary approach and assumes that what has happened in the past could happen in the future. I think that it is instructive to consider the options if a linear decline in (log) egg numbers is observed.

1. Assume that a linear decline will happen in the future (the EA/NRW model approach). If you are correct, then taking remedial action will hopefully resolve the problem. If you are wrong, then your remedial actions were unnecessary.

   OR

2. Assume that a linear decline will NOT happen in the future (which is essentially the time series approach proposed by the consultant statisticians). If you are wrong, then this could cause damage to the fishery because remedial action has not been taken. If you are correct, then you won't have taken remedial action unnecessarily.

5.8 Of the options above, I think that 1 is best because the adverse consequence (unnecessary remedial action) is far less serious than the adverse consequence in 2 (damage to the stock). This is clearly a value judgement, in line with the Precautionary Principle, and one that needs to be considered by fisheries experts, rather than statisticians.

[10] Appendix 4, NRW/3(E).

6 Conclusions

6.1 My view is that, for the time being, we should carry on with using the precautionary approach currently in use by the Environment Agency and NRW, which I continue to believe is fit for purpose.

7 Statement of Truth

7.1 I hereby declare that:

I. This proof of evidence includes all the facts which I regard as being relevant to the opinions that I have expressed and that the inquiry's attention has been drawn to any matter which would affect the validity of that opinion;

II. I believe the facts that I have stated in this proof of evidence are true and that the opinions I have expressed are correct; and

III. I understand my duty to the inquiry to help it with matters within my expertise and I have complied with that duty.

Jonathan Barry

Cefas

on behalf of Natural Resources Wales