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

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PROOF OF EVIDENCE

OF

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on behalf of

CENTRE FOR ENVIRONMENT FISHERIES AND AQUACULTURE SCIENCE (CEFAS)

and

NATURAL RESOURCES WALES

NOVEMBER 2018

From George Eustice MP
Minister of State for Agriculture, Fisheries and Food 25th May 2018

Mr John Rawlinson
Chairman Ribble Fisheries Consultative Association
Our ref: P02018/09740/MH
Thank you for your email of 16 April concerning the new Environment Agency (EA) measures being proposed to regulate the exploitation of salmon.

You have principally raised concerns about the statistical validity of the salmon stock assessment methodology. Cefas, the EA and National Resource Wales have considered your letter, and the accompanying review commissioned by angling groups affiliated to the Angling Trust and conducted by independent statisticians. They do not, however, share the view that the assessments which underpin the current need for action are 'formed on invalid statistical principles and use modelling that has major flaws and weaknesses.
A regression model using year as a predictor variable in this context is not a valid approach. This is time series data and should be modelled using time series approaches such as moving averages or ARIMA models.

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

1 Overview

The current methods for setting conservation limits and management targets in England & Wales, and for assessing compliance with these, have been in place for many years. They were developed in line with agreed international guidelines by a respected statistician. They were subject to consultation and peer review during their development and subsequently.
Could we be informed of the statistician and the corresponding international guidelines ? And provided with a copy of the peer review and statistical review ? We encountered international models in our own review that were completely at odds with this approach.

We recognise that there are some uncertainties in the data used in assessments, that the assessments rely on certain assumptions and that procedural improvements are always possible. Scientists from various Government agencies met at the end of last year to start considering ways in which the current procedures might be improved and to plan ways for taking this forward.
However, we remain of the view that the current assessment procedures, alongside other

independent measures of stock status, such as adult counts and juvenile surveys, provide a reliable basis for evaluating the status of salmon stocks in England and Wales.
This statement does not appear to be borne out by the model predictions versus the actual stocks that materialised.

We do not share the view that the assessments which underpin the current need for proposed management action are: *'formed on invalid statistical principles and use modelling that has major flaws and weaknesses'*.
We believe that many of the points raised in the review by O'Hagan and Fop are unfounded and appear to be based, in part at least, on a misunderstanding of the procedures applied.
If there have been any legitimate misunderstandings this perhaps suggests that the methodology needs to be made more clear and explicit and available. Nowhere were we able to find evidence in the documentation of the Bayesian approach mentioned. However even with these details available it would not overcome some fundamental concerns such as the use of regression based on year/ non use of time series methods/ lack of model validation and definitions such as "four out of five years on average"

In particular, we emphasise that the model in use is based on a Bayesian statistical approach rather than the frequentist interpretation that has been assumed. In this context, we note that the consultant's assessment was based on an overview of the methodology published in the annual salmon stock status reports for England and Wales and not the full technical details. We recognise that this may account for some of the apparent differences in interpretation.
The current model estimates future egg deposition trajectories in a Bayesian frameWork that includes an autoregressive term *This should be detailed. It does not appear to have a strong enough influence in correcting for the recent upward trends. In an example provided by email only a standard linear regression was performed and this tallied with the reports.* and 20-percentile regression to estimate compliance with the management objective — i.e. meeting conservation limit (CL) in four years out of five.
Previously cited as four years out of five on average - 2007-16 years

In this instance, we consider fitting a linear trend to the data is appropriate to evaluate temporal trends in egg deposition and the inclusion of "year" as a proxy variable is prudent because it captures the potential influence of multiple explanatory variables at once.
It would be much better to include these as standalone variables for transparency, understanding and model interpretation and accuracy. Some of these variables may have offsetting effects and it makes no sense to collapse them into year.

2 Specific comments

The following section addresses various specific issues raised in the review by O'Hagan and Fop.

2.3 **Use of a linear trend**

We acknowledge that the exact process to model egg counts might be seen as subjective and open to the preferences of the modeller. A regression-type approach was favoured on the assumption that there could be some underlying driver that is behind any decrease (or increase) in egg numbers and that this is represented (albeit, possibly in a proxy way) by time in a regression model. We have also recognised the need for a precautionary approach to avoid the possibility of salmon stocks reaching unfavourable levels. We thus consider it reasonable to base decisions on the precautionary question: "what if levels fell in the same linear fashion in the next X years". In this instance, a period of 5 years has been chosen since this approximates to one generation in the salmon life-cycle. The use of a 20-percentile regression to fit a linear trend to the data has been considered appropriate given the management objective of meeting or exceeding the CL in four years out of five. *This was previously cited as four years out of five on average. What is the justification for linearity ?*

We recognise that patterns of egg deposition are likely to vary between rivers and overtime. However, we consider that it is important to apply a consistent methodology and that linear trends continue to provide a reasonable fit to the data in many cases (and represent a suitable approach overall). *What evidence do you have that the fit is reasonable ? It appears to be distinctly unreasonable when projections are compared to actual outcomes.*

Time series methods were considered during preliminary discussions to establish the current system.

However, it was felt that moving average and autoregressive approach might result in predictions that relied too much on the most recent changes in the data. In the event, it was therefore decided to assume some underlying trend.

We recognise that it could be informative to explore possible alternative scenarios by means of General Additive Models and will aim to investigate this further as part of the planned review of methods. We note, however, that whichever model is used, predictions into the future are problematic and can only assume that what has gone on before will continue.

This is a gross oversimplification. A good model that is valid for its predictors will make robust and flexible predictions into the future. These do not have to be "problematic". What you say here is only true of the current approach, which slalvishly follows an oversimplified, dated linear trend without valid predictors.

2.4 **Applying a 20-percentile regression**

The justification for fitting a 20-percentile regression to the data relates to the management objective of meeting or exceeding the conservation limit (CL) in 4 years out of 5. In line with international guidelines, and the precautionary approach, managers should aim to ensure that CLs are achieved with a high degree of probability. In England and Wales; managers have specified that this level should be set at 80% (other jurisdictions apply similar levels). The current method fits a 20-percentile regression line to the data and calculates the probability that this regression line is above the CL, and thus that the CL will be exceeded in four years out of five (the management objective). We consider that this approach is reasonable and appropriate when done in a Bayesian context.

WHY is it reasonable ? Why not use a conifdence interval around each predicted value, which would be a far more standard approach ? The entire methodology around the 20 percentile regression calculations is completely vague and unclear. There seems to be a fundamental misunderstanding that 20 percentile regression corresponds to 80% probability. This is not the case.

2.5 **Number of observations used in the assessment**

We do not share the view that using ten observations to compute the regression line makes the current assessments invalid. The number of observations affects only the variability of the assessment. However, the uncertainty of any assessment will be a function of the variability of the data around the model and the number of observations. Ten annual observations were chosen to balance having enough information to estimate the model and be a biologically relevant period for a temporal trend that covers two generations of the salmon life-cycle. Time-series or moving average based approaches are unlikely to improve the model predictions, because an autocorrelation term has already been included in the calculation of log(egg deposition) estimates prior to inclusion in the regression model.

We further note that there is no biological justification for changing the egg deposition calculations to apply over shorter periods of time than annually because Atlantic salmon only spawn once per year.

We are confident they would improve the predictions and illustrated this in our examples. The current approach completely misses recent increasing trends because it is overly anchored to a more dated decreasing trend that no longer applies.

2.7 **Model validation**

We accept the suggestion that some form of model validation might be a good addition to the assessment. This could be achieved by examining retrospective patterns in the predictions of egg deposition over time. There are, however, certain caveats that would need to be taken into account in exploring retrospective patterns.

Model validation is a vital part of model assessment. It should never have been overlooked.

The current process considers what the egg deposition levels might be in 5 years' time if the linear projection is maintained.

There is no statistical basis for assuming a linear trend. Indeed the trend is distinctly non linear.

Where a fall is projected, this might not actually happen, but in terms of stock management it would be prudent to assume that it might.

This defeats the purpose of modelling. You will always be able to find a bad model that predicts a fall. The goal is to find a good model that will make accurate predictions and then take action based on that information.

3 Conclusion and next steps

We remain of the view that the current Bayesian assessment and forecast methods for evaluating compliance with the management objective have been carefully considered, are fit for purpose and are consistent with the precautionary approach. As such, we are satisfied that the current procedures provide an adequate basis for taking management action to safeguard stocks.

If this is actually true, you could demonstrate it with a robust model validation exercise. We are confident that if you do, you will find that the alternative approaches we have outlined are more suited to capturing the underlying trend and should be taken as the basis for stock projections.

We recognise, however, that alternative assessment approaches are possible and, as noted previously, we will be considering these as part of the ongoing review of procedures. Amendments that might be considered include: investigating whether linear, quadratic, or other, potentially more subjective, models most frequently have the best fit to the data across rivers, and undertaking some form of retrospective analysis for model validation.

These are all important and validation is crucial. It should have been part of the model building process and ongoing model application, not confined to a periodic review.

The precise details of the methodology would also be documented carefully and publicised more widely to improve transparency in the procedures used.

This is also very important. Current documentation is very poor.

In closing, we would note that salmon stock assessment procedures applied in neighbouring jurisdictions may differ in their detail, but are built around the same international guidance and precautionary principles as our own. In both Scotland and the Republic of Ireland, recent assessments have also indicated substantial declines in salmon stock status and have resulted in extensive further controls on exploitation in order to protect declining stocks.

This is also very important. Current documentation is very poor.

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