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/2

PROOF OF EVIDENCE

OF

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SENIOR TECHNICAL ADVISOR ON SALMONIDS

on behalf of

NATURAL RESOURCES WALES

NOVEMBER 2018

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1 Personal background

1.1. My name is Ian Davidson. I am the Senior Technical Advisor on Salmonids for Natural Resources Wales (**NRW**). I have worked for NRW and its predecessor bodies for 33 years and have been primarily involved in the monitoring and assessment of salmon and sea trout. This includes:

(i) running the 'Dee Stock Assessment Programme'[1] – a long- term and comprehensive monitoring programme for salmon and sea trout on the River Dee, North Wales, which began in 1991;

(ii) leading in stock assessment and related matters at a national level for NRW and its predecessor organisations; and

(iii) involvement in areas of fisheries ecology and management associated with (i) and (ii), including research and peer reviewed publication, and representation on national and international scientific working groups.

1.2. I have a BSc in Zoology and an MSc in Applied Hydrobiology.

[1] The Dee is one of few rivers in the UK or further afield with facilities and resources (e.g. fish traps) to monitor the abundance and biological characteristics of salmon and sea trout at key life stages. This generates unique data sets which are used, in the widest sense, to improve scientific understanding and better inform management.

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2. Personal background

2.1. This statement explains how NRW has assessed the status of salmon and sea trout stocks in Wales, and how that assessment has informed its decision to promote the protective measures set out in the byelaw proposals. More specifically this statement:

a. describes the main types of fisheries monitoring data routinely collected by NRW for assessment purposes identifying what, in general terms, the patterns and trends in these data sets (updated to 2017) indicate about the health of these populations.

b. examines the use of Conservation Limits as a means of assessing salmon stocks and (more recently) sea trout stocks in Wales and how compliance outcomes inform management decision making.

c. explains why the use of Conservation Limits in the assessment of sea trout stocks in Wales is an improvement on the previous approach which focussed on fishery rather than stock performance.

d. sets out the latest (i.e. 2017) assessments of Conservation Limit compliance for salmon and sea trout - a year-on from the NRW's Technical Case supporting the byelaw proposals[2] – and examines what these latest assessments say about stock status.

e. reviews the evidence base as outlined above and sets out why NRW concludes that the status of many of the river stocks of salmon and sea trout in Wales is poor and at risk of further deterioration, and why, in conjunction with other remedial measures (e.g. to improve environmental quality) the additional protection provided by the Wales Rod and Line (Salmon and Sea Trout) Byelaws 2017 and the Wales Net Fishing (Salmon and Sea Trout) Byelaws 2017 (together the **All Wales Byelaws**) is necessary.

2.2. In addition to my main proof of evidence and summary proof of evidence, I have provided an Appendix setting out full size figures and tables.

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[3].

[2] **APP/4**.

[3] **NRW/1(D**).

3 Evidence base for assessment of fish populations

Provision of fisheries monitoring data

3.1 Monitoring programmes for salmon and trout/sea trout undertaken by NRW provide the evidence base to evaluate the status of fish stocks in Wales, and inform related management decision making. This includes consideration of historic data sets collected by bodies which preceded NRW – including the Environment Agency (**EA**) and the National Rivers Authority (**NRA**).

3.2 These monitoring programmes focus on three key activities:

a) The collection, collation and reporting of rod and net catch statistics. These statistics are available for most rivers and coastal fisheries in Wales since 1951 and, in some cases, for much longer[4]. Rod catches were recorded more consistently from 1975 when regional licence-based catch return and reminder systems were introduced. These were replaced in the early 1990s with a single, national (E&W) rod licence and catch return system which has collected catch and release, and fishing effort data in a broadly consistent way since that time. Catch statistics for all net and rod fisheries in E&W are reported annually[5]. Catch data serve as indicators of stock abundance as well as providing information on the size/age composition of returning fish. The long time-series of catch records available are un-matched in the length of time they cover compared to other sources of fisheries data, and so catches provide invaluable insight into long-term patterns and trends in abundance. Such patterns and trends are examined here for Wales to give perspective into the likely current performance of stocks compared to the past. In doing so, other factors which might affect interpretation of catches are considered e.g. declaration rates and fishing effort.

b) Use of fish traps and automated fish counters – primarily to enumerate numbers of returning adult salmon and sea trout. These are resource intensive programmes limited to a few river systems but collecting some of the most detailed information available on the abundance and composition of returning stocks. In Wales this includes:

[4] **ACC/26**.
[5] **POL/25**.

- the ‘Dee Stock Assessment Programme’ a long-term term monitoring programme for salmon and sea trout on the River Dee which includes trapping and tagging of both smolts and adult fish to estimate abundance and provide associated biological information This programme began in 1991 and is one of the longest running and most comprehensive programmes of its type in the North Atlantic region;
- operation of an acoustic fish counter on the River Teifi - producing salmon run estimates since 2010; and
- Cardiff Bay Barrage programme on the River Taff/Ely where NRW has operated a fish counter/trap (on behalf of the harbour authority) to provide salmon and sea trout run estimates since 2008.

Validated trap and counter data produce the most reliable estimates available on adult run. These are confined to a few rivers - 3 in Wales and 8 in England - most of which provide run data for salmon only (not sea trout). This examination focusses on the patterns and trends in run data for salmon from the ‘counted’ rivers in Wales. On the Dee, additional information available on changes in the sea age composition of returning salmon (based on scale readings from trap sampled fish), is also explored.

c) Annual monitoring of the abundance and distribution of juvenile salmon and trout populations using electrofishing methods. Electrofishing surveys to assess the distribution and abundance of juvenile salmon and trout have been undertaken on most catchments in Wales - with the earliest data sets extending back about 30 years. The current Electrofishing programme (c.2002 onward) comprises a temporal element, where a number of fixed sites are surveyed annually, and a spatial element where considerably more sites spread across the whole catchment are surveyed every 6 years as a “snapshot” of catchment fish populations. The number of sites in the temporal and spatial programmes vary between catchments and relate to the size of the catchment. NRW’s electrofishing survey programme and associated sampling methods are briefly discussed. Survey results are examined in relation to the marked reduction in juvenile abundance observed in 2016, focussing on a few catchments which have been subject to follow-up investigations. Results of the wider survey programme are presented on a catchment-by-catchment basis in Annex 1 to the Technical Case[6].

'All Wales' net and rod catches

3.3 This section examines patterns and trends in the national 'all Wales' catch of salmon and sea trout reported by net and rod fisheries (i.e. the combined catch of individual river and coastal fisheries). It refers to catches reported from 1975 to present, a period in which different regional and national catch-recording systems have operated (see paragraph 3.2a, above).

Reporting rates

3.4 For rod fisheries, correction factors have been applied to declared catches to attempt to account for under-reporting.

3.5 From 1994 onwards, a national (E&W) catch declaration rate of c.90% has been estimated from adjusted licence return figures[7]. This equates to a constant raising factor of x1.1.

3.6 Additional catch correction factors have been applied following concerns about the operation of a newly introduced on-line catch reporting system in 2015 (to supplement the existing paper return system). On average, these have increased the national raising factor from x1.1 to c x1.3[8].

3.7 For rod catches prior to 1994 back to 1975, various raising factors have been applied at different times depending on the nature of the reporting system[9].

3.8 No attempt has been made to correct catches reported from the net fishery for under-declaration because of the lack of information. However, since the introduction of the carcass tagging and log book scheme in 2009[10] declaration rates are considered to have been close to 100%.

3.9 Time-series of 'all Wales[11]' net and rod catches for salmon and sea trout – adjusted as described above – are shown in Figure 1.

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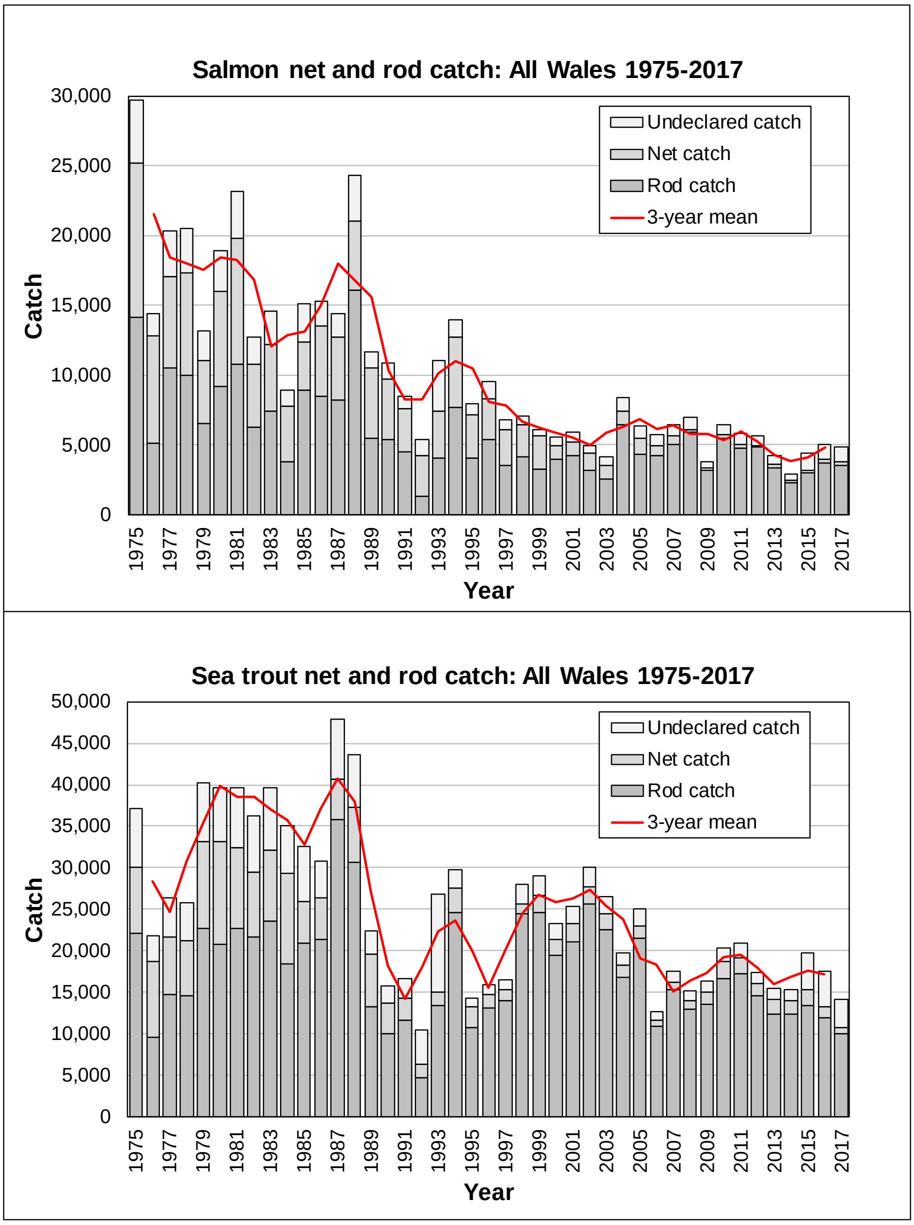
[6] **APP/4.**
[7] The method used is described in **ACC/12** and **POL/24**.
[8] See **ACC/25** and **ACC/28**.
[9] These factors are detailed in **POL/24**.
[10] **APP/4**.
[11] Excluding the River Severn.

***Figure 1**. 'All Wales' net and rod catches for salmon and sea trout, 1975-2017.*



3.10 For both species, while catches show considerable variation year-on-year, the overall pattern is one of progressive decline.

3.11 In the case of salmon, catches have reached a 40-year low in the last few years – marked by a rolling 3-year mean catch (nets and rods combined) of c.3,800 fish in 2013-2015, less than 20% of the maximum recorded at the start of the period (Figure 1).

3.12 For sea trout, catches in the last decade have also been among the lowest of the time-series, but the decline has been less pronounced than in salmon (c.35% of the maximum).

***Figure 2**. Angling days fished in England and Wales, 1994-2017*

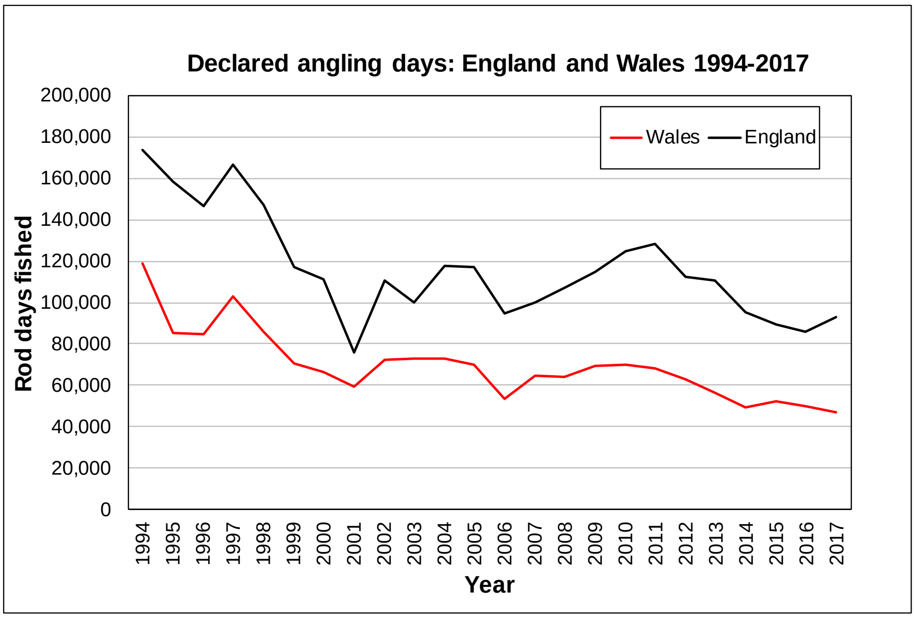
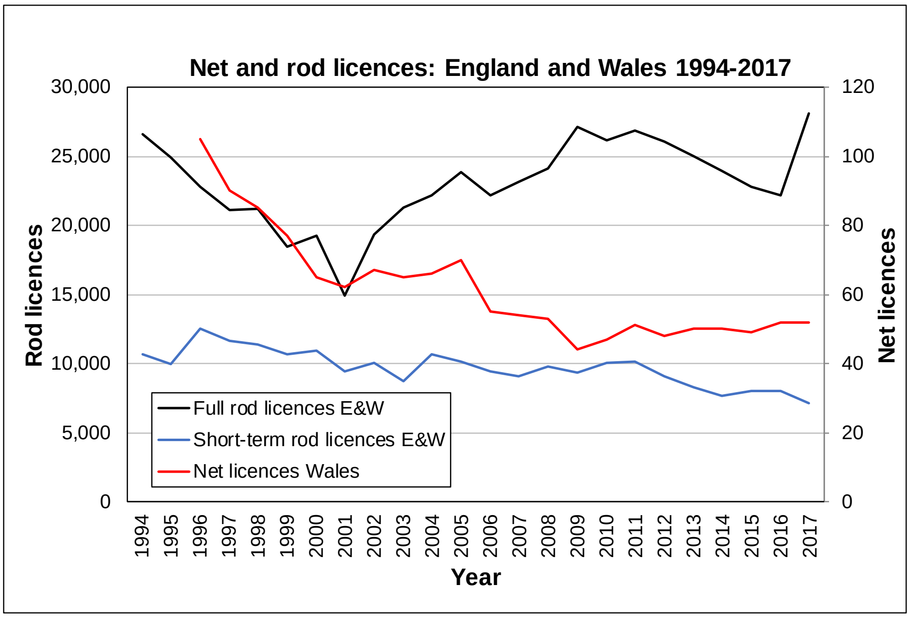


***Figure 3.** Numbers of net and rod licences issued in England and Wales, 1994-2017*



Fishing effort

3.13 These declines in catch would be moderated by changes in fishing effort. For example, numbers of net licences issued in E&W has fallen by c.75% since the mid-1970s. Better records of rod fishing effort (as days fished) have been collected since the introduction of the national licence in the early 1990s. The last 25 years have seen a general decline in the declared number of angling days fished, although since c.2000, this measure of effort has remained relatively stable (Figure 2). In contrast, the number of full season rod licences issued in E&W has been increasing since c.2000 (Figure 3).

3.14 The ‘all Wales’ view of catch trends presented in Figure 1 reflects patterns of decline evident on many rivers[12]. However, there are exceptions to this pattern, for example, improved rod catches of sea trout in recent years on a number of North Wales rivers e.g. Dyfi, Ogwen, Conwy, Clwyd, Dee.

3.15 In the case of salmon, a down-turn in catch since 2010 has occurred during a period when catches were already relatively poor, and so gives particular cause for concern (Figure 1). This decline can be seen within the rolling 10-year assessment period used to evaluate Conservation Limit compliance for the Technical Case (i.e. 2007-2016). Similarly, the same decline is encompassed within the latest (2017) assessment[13].

Adult return estimates from automated counters and traps.

Run size

3.16 Catch-independent measures of adult return for salmon are obtained on three rivers in Wales from automated counters or traps: (i) Dee (trapping and mark-recapture); (ii) Teifi (multi-beam sonar) and (iii) Taff (Vaki and DIDSON counters). The Dee also produces the same estimates for sea trout.

3.16.1 Salmon counts from these three Welsh rivers (Figure 4) all indicate similar patterns of recent decline to those suggested by catch returns (as do salmon counts from a number of rain-fed systems in England – namely Tamar, Fowey, Lune, Kent[14].

3.16.2 The counts on the Taff, Teifi and Dee were the lowest on record in 2017. In all three cases, this followed a period of almost year-on-year decline over the last decade, with little sign that this downward trend may be abating (Figure 4).

3.16.3 This and other evidence, for example (i) highly correlated time-series of catch and count data for both salmon and sea trout, and (ii) common patterns

[12] More details are given in **APP/4.**

[13] See section **5.18** below.

[14] See **ACC/25, ACC/28** and **ACC/23**.

evident in sometimes disparate catch records collected over many years[15], strongly suggest that catch returns do provide meaningful indicators of abundance.

Run composition

3.17 The time-series of salmon run data shown in Fig 4 for the Taff, Teifi and Dee refer to the run as a whole. On the Dee, where scales taken from trap sampled adult fish are used for ageing purposes, each single annual run estimate can be broken down into its sea age components.

3.18 On this basis, separate time-series of run estimates have been obtained for 1-sea winter (1SW) salmon or 'grilse' and multi-sea winter (MSW) fish. This reveals two contrasting patterns in the data – a marked reduction in the grilse component of the Dee run, but some improvement in the return of MSW salmon (Figure 5).

3.19 For grilse, the run has declined by more than 80% from a maximum 3-year mean of 5,400 fish in 1993-95 to a minimum of 860 fish in 2015-2017. The equivalent statistics for MSW salmon show an improvement in run of c.50%, from a minimum of c.1,200 fish in 2000-2002 to 2,300 fish in 2011-2013.

3.20 Despite the improvement in numbers of MSW salmon, levels of egg deposition from both sea age groups have been insufficient to meet the Conservation Limit on the Dee[16].

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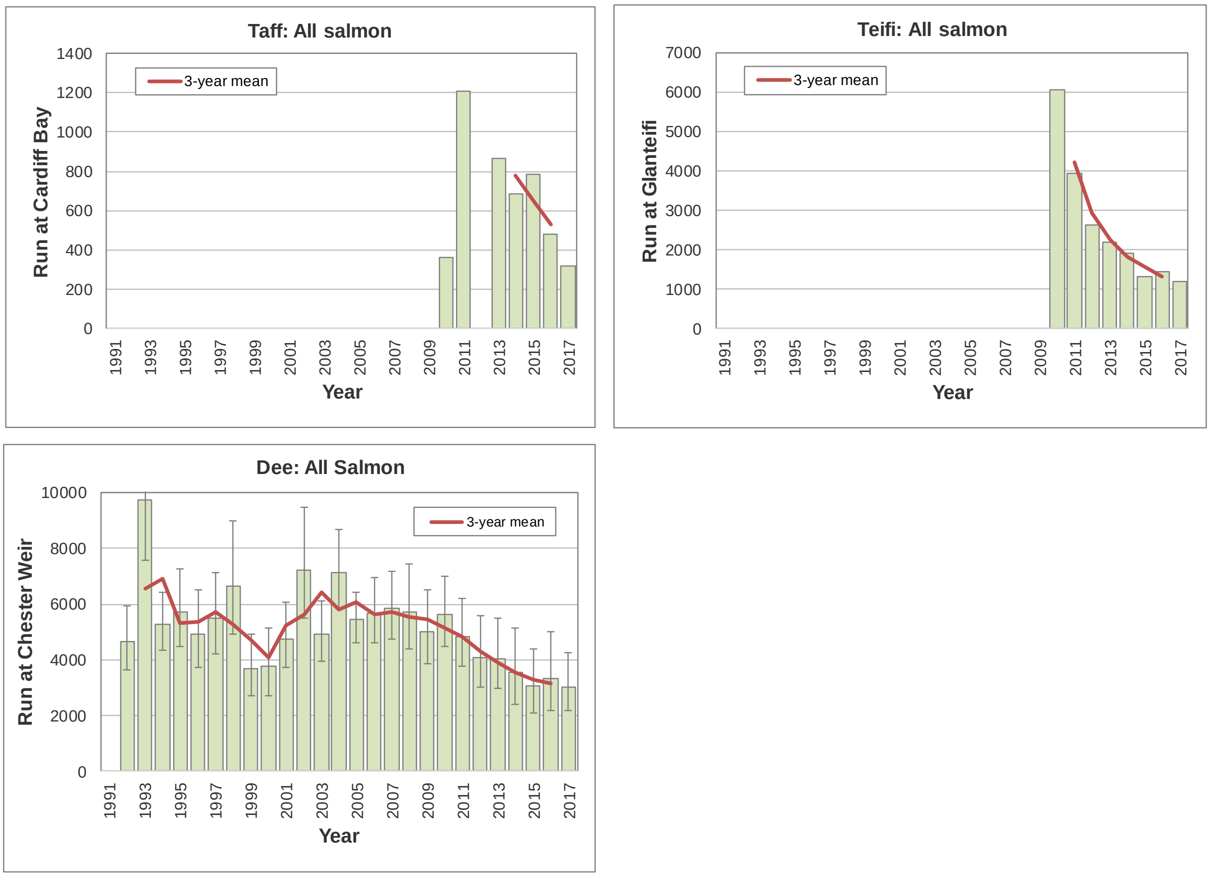
[15] **ACC/21**.
[16] **ACC/25, ACC/28, ACC/23.**

Figure 4. *Run estimates for adult salmon from counters/traps on the rivers, Taff, Teifi, and Dee, 1992-2017.*



3.21 This change in the contribution of 1SW and MSW fish to the salmon run on the Dee is also apparent on other monitored rivers in England[17] and elsewhere[18].On the Dee and the Tamar it has been associated with progressive decline in the size of returning fish of both sea age groups[19] – itself likely to be linked to environmental change in the North Atlantic influencing marine feeding and growth rates (e.g. slower growing fish may have to remain at sea for longer before they can mature and return to spawn).

3.22 The long-term data set from the Dee indicates that this may be part of a cyclical pattern - with the ratio of 1SW:MSW salmon in the last few years appearing similar to that 50 years ago when around 80% of the return was made up of MSW salmon[20].

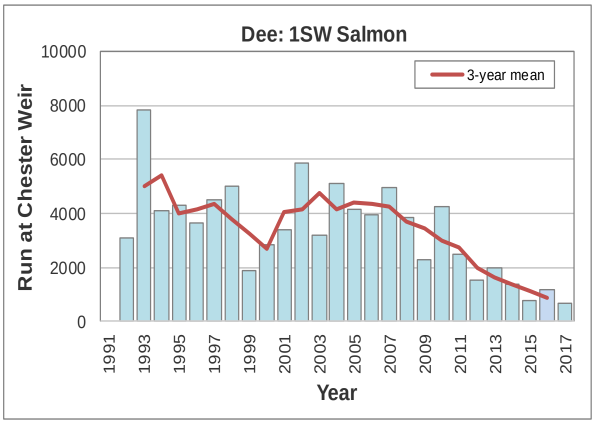
[17] **ACC/25, ACC/28**.
[18] **ACC/13, ACC/27**.
[19] **ACC/24, ACC/33**.
[20] **ACC/24, ACC/33**.

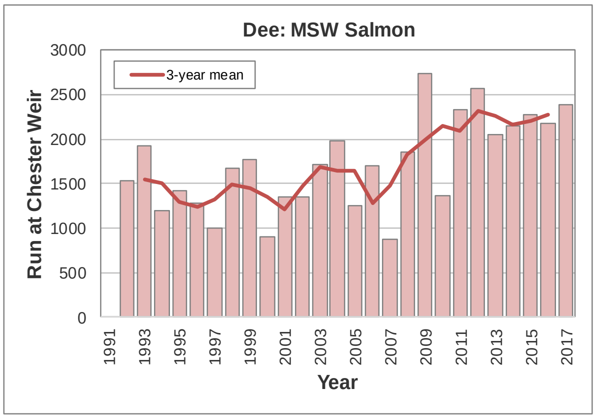
3.23 On the River Tweed in Scotland, similar long-term changes in abundance of grilse and MSW salmon have been identified from historic data sets[21]. These changes have been linked to cyclical processes affecting environmental conditions in the North Atlantic.

3.24 While we may be experiencing the trough of such a cycle now we cannot be certain that this is the case. Factors such as global warming - not so evident or potentially damaging 50 years ago may also be at play. The precautionary response is to take steps now to protect stocks and not to be complacent and expect a natural recovery which may take a decade or more to be realised, if at all.

3.25 As most of the principal salmon rivers in Wales are grilse dominated – marked reductions in grilse numbers are likely to be a significant causal factor in the failure of many Welsh rivers to meet their Conservation Limits.

***Figure 5**. Run estimates for 1SW and MSW salmon on the River Dee, 1992-2017.*





Juvenile salmon/trout abundance

3.26 The catch and count data referred to above relate to numbers of adult fish returning to the catchment as a whole. Assessment of compliance with Conservation Limits – which is dependent on these data sets - also operates at the catchment scale (i.e. applies to the whole river stock).

3.27 In contrast electrofishing surveys for juvenile salmon and trout provide abundance estimates at the site scale (site length c.30-50m) and principally target small to medium sized tributaries (usually less than c.10m wide).

[21] **ACC/27**.

3.28 The majority of sites are sampled using a 'semi-quantitative' single-run survey method to provide a count of fish identified to species (salmon/trout) and age group (fry or parr). Single run counts are raised using sampling efficiency estimates (dependent on the fish group and site dimensions) to produce total abundance figures for each site. These abundance figures are usually expressed as densities (e.g. numbers of fish per 100m^2.)

3.29 A few electrofishing sites in Wales are also surveyed using 'quantitative' fishing methods where the site is fished through multiple times (up to 2 or 3) rather than once as with the semi-quantitative method (above). Usually, a reduction in catch occurs with each successive fishing (fish are removed from the site and counted at each run through). This reduction with successive fishings enables direct estimates of total abundance to be made.

3.30 Electrofishing coverage varies annually. A 'temporal' programme aims to survey the same set of fixed sites each year to detect year-to-year variation in fish abundance (including trend detection). In smaller catchments this programme may sample just a single site each year, whereas in larger catchments, a number of sites may be sampled each year. On the River Wye, for example – one of the largest catchments in Wales - up to 24 fixed sites are sampled each year.

3.31 A 'spatial' survey programme aims to sample catchments on a more intensive basis every 6-years, sampling a larger number of sites to provide a more comprehensive picture of distribution and abundance.

3.32 Results from electrofishing survey programmes are summarised, catchment by catchment, up to 2017, in Annex 1 to the Technical Case[22] and in the Technical Case.

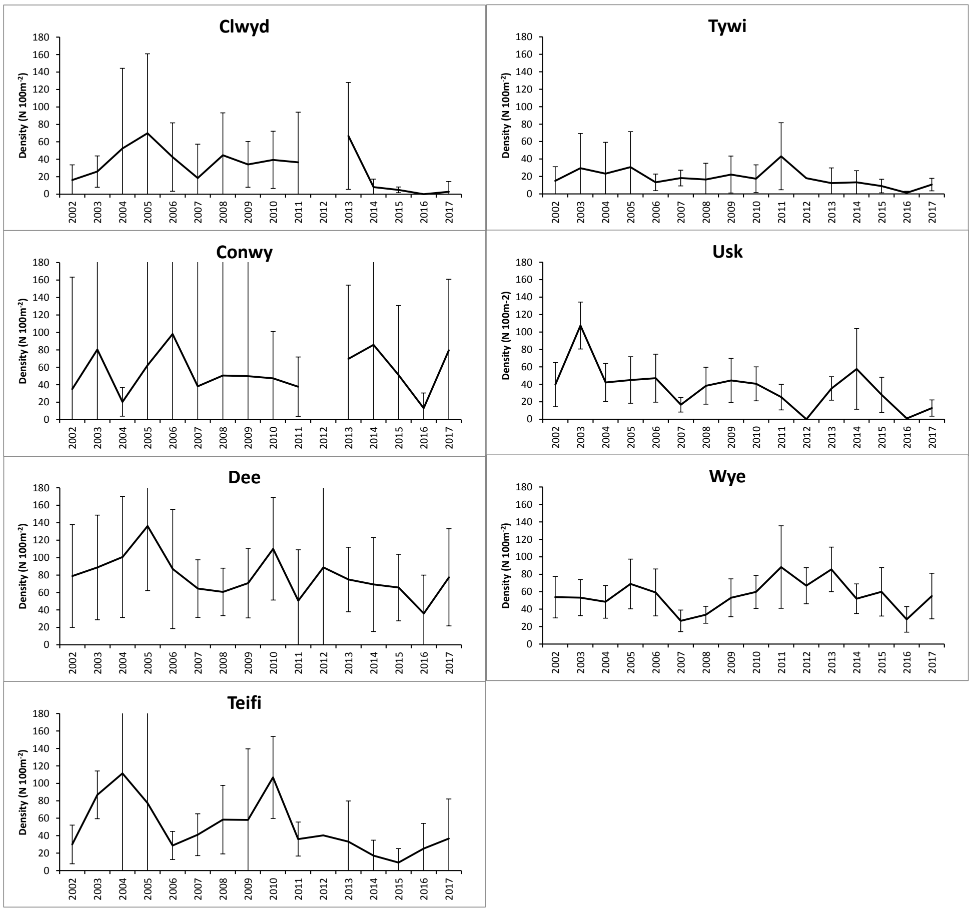
3.33 Neither temporal nor spatial electrofishing programmes are designed to provide annual measures of total fish production ('standing stock') at the catchment scale – i.e. comparable to adult assessments. However, electrofishing data are used at the site and sub-catchment scale to identify and address underperformance and potential environmental pressures (e.g. for Water Framework Directive assessment of Water Body status and Condition Assessment of Special Area of Conservation rivers, etc.)[23].

[22] **APP/4**.
[23] **APP/4**.

3.34 Electrofishing survey results from 2016 did, however, detect a marked and widespread reduction in abundance of salmon and trout fry (and to a lesser extent parr) across a number of rivers in Wales.

3.35 This effect was more pronounced in some catchments (e.g. Usk, Tywi, Conwy and Clwyd) than others (e.g. Wye, Teifi and Dee); for example a 94-100% reduction in salmon fry recruitment (against long term averages) in the former catchments compared to a 51-56% reduction in the latter group[24].

Figure 6 *Annual variation in mean densities of salmon fry in principal Welsh catchments, 2002-2017 (95% confidence intervals shown).*



3.36 While levels of recruitment in 2017 were better (Figure 6), this leaves significant cause for concern about numbers of adult salmon returning from the 2016 year-class – particularly on the worst affected rivers (a factor addressed in the byelaw proposals for the River Usk[25].

[24] **ACC/14**.
[25] **APP/4**.

3.37 A similar ‘failure’ of recruitment in 2016 was identified from EF surveys on migratory salmonid rivers in England, and further afield[26].

3.38 The 2016 event coincided with a period of extreme weather in the winter of 2015 (in part, at least, linked to ‘Storm Desmond’[27]) producing, on some river systems, record high flows and river temperatures[28].

3.39 Such extreme conditions, occurring at a time when adult fish (the parents of fry hatched in 2016) would have been spawning or preparing to spawn, have been identified as possible causes of recruitment failure

3.40 For example, unseasonably warm winter temperatures (c.11-12 Centigrade) may have compromised reproductive success and/or subsequent egg or fry survival. Similarly, extreme flow events may have led to redd washout or clogging of redds through sedimentation.

3.41 The events of 2015/2016, including the consequences for fish populations in Wales, the potential causes, and long-term implications are the subject of an ongoing investigation expected to report early in 2019.

3.42 Furthermore the majority of rivers in Wales (and England) have, in recent years, seen levels of salmon spawning/egg deposition well below Conservation Limits[29] which has increased the likelihood of poor recruitment and, as a consequence, has left populations less resilient to the impacts of adverse episodic events such as the extreme winter weather conditions of 2015/16.

3.43 All these factors have implications for the future vulnerability and status of salmon (and trout/sea trout) stocks in Wales and the wider southern Atlantic area in view of climate change scenarios and other environmental pressures.

Conservation Limits and the assessment of salmon stocks in Wales:

3.44 Following the advice of ICES (International Council for the Exploration of the Sea) and NASCO (North Atlantic Salmon Conservation Organisation), Conservation Limits

[26] **ACC/28**.
[27] Storm Desmond was an extratropical cyclone and fourth named storm of the 2015–16 UK and Ireland windstorm season, notable for directing a plume of moist air, known as an atmospheric river, which brought record amounts of orographic rainfall to upland areas of northern Atlantic Europe and subsequent major floods
[28] **ACC/22**.
[29] **APP/4, ACC/28**.

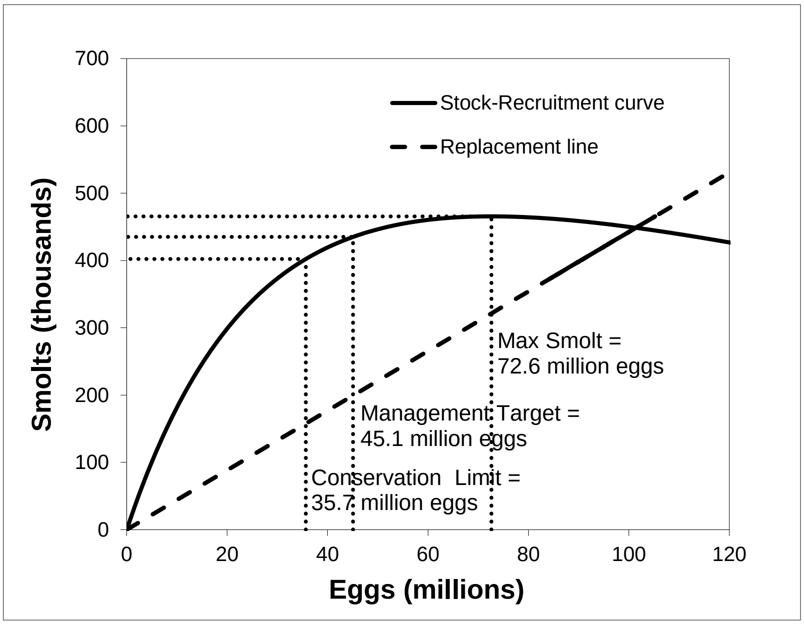
and associated Management Targets have been used to assess the status of salmon stocks in England and Wales (E&W) since the early 1990s. This approach was enshrined in a Ministerial Direction in 1998[30] which, among a number of actions, required Conservation Limits to be set and used to assess stocks annually on 64 Principal Salmon Rivers in E&W[31].

3.45 The Conservation Limits derived for all 'principal salmon rivers' have been based on modelled stock and recruitment curves which relate spawner or egg numbers to smolt output (Figure 7). Stock and recruitment curves have been developed from river-specific measures of the extent and quality of freshwater habitat. They also incorporate information from a stock and recruitment relationship produced from long-term monitoring data collected on the River Bush, N. Ireland[32].

3.46 In addition to the stock and recruitment curve, the 'Replacement line' shown in Figure 7 is also required to set the Conservation Limit. In this case, the Replacement line effectively converts smolt output ('Recruits') back to returning adult spawners and their egg contribution ('Stock'). Combined with the stock and recruitment curve this forms a simple life-cycle model. To define the Replacement line in Figure 7, information is required on sea survival and the average size/fecundity of returning fish (again based on observations from index monitored rivers as well as river specific data)[33].

[30] **LEG/13.**
[31] See also paras 4.3 and 4.4 of **NRW/4**, and 3.1, 3.2, and 4.1 to 4.3 of **NRW/1**.
[32] **ACC/29.**
[33] **ACC/29.**

Figure 7. *Conservation Limit and other reference points defined by the stock-recruitment curve and replacement line (where Stock = Eggs and Recruits = Smolts)*



3.47 Conservation Limits serve as a 'limit' reference point below which further reductions in spawner numbers are likely to result in a significant fall-off in smolt production.

3.48 Compliance procedures require that spawning levels are above the Conservation Limit in four years out of five, (i.e. 80% of the time) in order for a stock to formally 'pass' its Conservation Limit. This is the 'Management Objective' and the associated 'Management Target' (a 'target' reference point) defines the average stock level required to achieve this. The compliance procedure ensures there is a high probability that stocks are exceeding their Conservation Limit – a precautionary approach in-line with the recommendations of ICES and NASCO, and in-keeping with the methods applied by other jurisdictions[34].

3.49 The Conservation Limit and Management Target reference points are both indicated on the stock and recruitment curve shown in Figure 6. A further reference point – 'Maximum Smolt' - is also shown to identify the maximum smolt output that may be expected from a catchment.

3.50 For each river stock, estimates of spawner numbers and egg deposition are produced annually. In most cases (except for rivers with counters or traps) these estimates are derived from rod catches and assumed angling exploitation rates (the latter primarily based on observations from counted rivers). Other information, for example relating

[34] See paragraphs 4.3 to 4.5 of **NRW/4**.

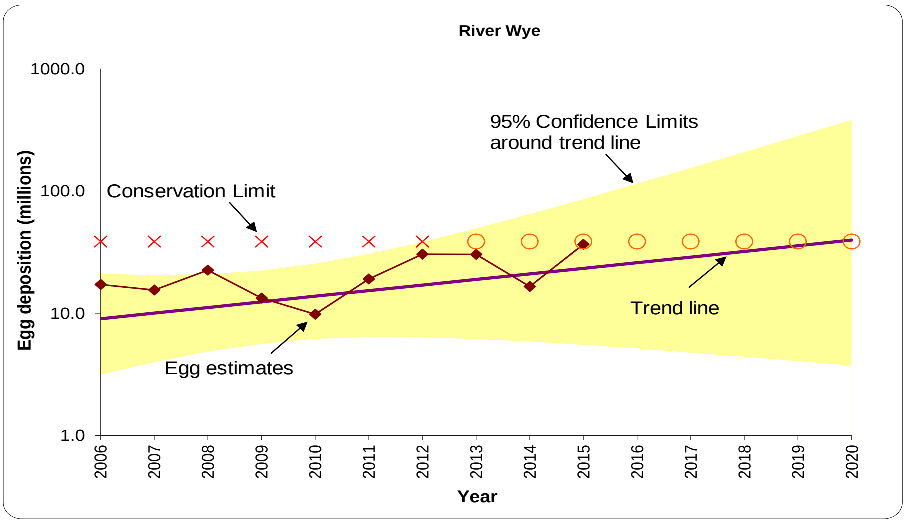
to the size and sea age composition of returning salmon, catch declaration rates and the egg contribution of rod-released fish is also built into spawner/egg estimates.

3.51 Compliance with the Conservation Limit is tested each year using a Bayesian statistical procedure which fits a 20 percentile trend line to the latest 10-year time-series of egg deposition estimates for each river and examines the position of that trend line (and confidence limits – or more correctly 'Bayesian Credible Intervals' - around that line) relative to the Conservation Limit.

3.52 If the 20 percentile trend line and its confidence interval fall completely below the Conservation Limit line in any one year, then the river is classified as 'At risk' in that year. If the 20 percentile trend line and its confidence interval fall completely above the Conservation Limit line in any one year, then the river is classified as 'Not at risk' in that year. If the 20 percentile trend line and its confidence interval fall in an intermediate position then the river is classified as either 'Probably at risk' (trend line below the Conservation Limit) or 'Probably not at risk' (trend line above the Conservation Limit).

3.53 Compliance with the Conservation Limit (i.e. 'risk' status) is normally reported for the current assessment year and projected (by extrapolation of the trend line) 5-years into the future[35].

Figure 8 *Compliance with Conservation Limits: Example graphical assessment for the River Wye, 2015*



[35] **NRW/3,** paragraph 4.5. Further details can be found at **ACC/25**.

3.54 The resulting compliance status for each river is examined annually against a 'Decision Structure' (**DS**)[36]. This provides a standard and consistent decision making process to guide management actions for the regulation of exploitation of stocks in both the rod and net fisheries. This recognises that exploitation control provides the most immediate remedy to shortfalls in spawning stocks. However it is also the case that longer term initiatives, for example the protection and restoration of river habitats, are fundamental to the conservation and future health of our salmon populations[37].

[36] Annex 4 of **APP/4** and **ACC/25**.
[37] See **NRW/1B** for an overview of these.

4 Conservation limits and the assessment of sea trout stocks in Wales

4.1 In contrast to salmon, no established methods of setting Conservation Limits or similar 'Biological Reference Points' (**BRPs**) for sea trout have been available in E&W (or elsewhere). The need to develop such methods has been widely recognised by fisheries biologists and managers, and to address this, an ICES Working Group – drawing on pan-European expertise and previous ICES Workshops - has recently been established with this aim. This group is set to report in 2019[38].

4.2 In the absence of stock-based reference points for sea trout – NRW and the EA have, for a number of years, routinely applied a fishery- based assessment to each of the principal sea trout rivers in E&W[39]. This assessment, which is based on trends in angling catch per unit effort (**CPUE**) data ('catch per day') is detailed below. These data have been collected via the national licence return since 1994.

4.3 More recently, however, an alternative stock-based assessment method has been developed by NRW and was applied, for the first time, on the 2016 return[40]. This method utilises angling catch data to derive run and egg deposition estimates for sea trout in much the same way that the same data sets are used in Conservation Limit compliance procedures for salmon assessment in E&W. For example, applying assumed angling exploitation rates to catch data to derive run estimates; adopting standard sex ratios and weight-fecundity relationships to generate egg deposition figures[41].

4.4 These catch derived estimates of run and spawner/egg numbers are used to generate stock and recruitment relationships for individual river stocks of sea trout, deriving from these relationships, reference points that are broadly equivalent to the Conservation Limits and Management Targets used in salmon assessment, and which allow use of the same trend-based statistical compliance procedures to assess the 'risk' status of the stock.

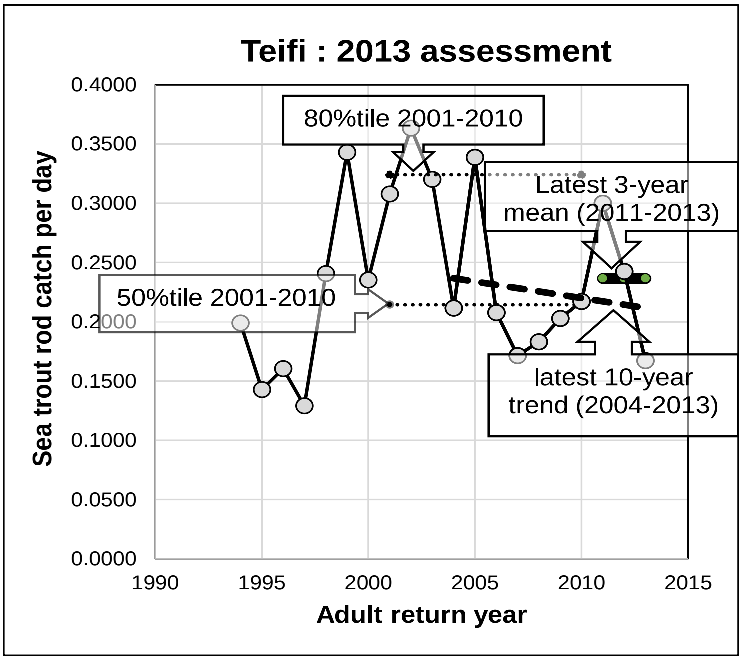
[38] **ACC/30** and **ACC/3.**
[39] **ACC/3.**
[40] **APP/4.**
[41] Further details are given in Annex 5 of **APP/4**.

4.5 The details of this method are also set out below[42], with procedures for estimating adult returns from rod catches, spawner numbers and levels of egg deposition summarised in Annex 5 of the Technical Case[43].

Catch per Unit Effort based assessment method

4.6 This assessment utilises time-series' of angling CPUE data – expressed as catch per day – collected via the national licence return since 1994. The assessment is undertaken annually on each river and includes (i) comparison of the most recent 3-year mean CPUE value to the 50th and 80th percentile values calculated from the previous 10-years of data ('reference period'), as well as (ii) an examination of the most recent 10 year trend in CPUE values . A graphical example of this assessment is shown below for the River Teifi. (Figure 9).

Figure 9 *Sea trout CPUE assessment: Example for the River Teifi, 2013*



4.7 'Risk' categories are assigned depending on the above measures of fishery performance and are set out in the table below[44]. While these risk categories appear similar to those applied in salmon assessment[45] they are not directly comparable. Their primary purpose is to provide an early warning about potential problems and so to prompt further

[42] And in more detail at **ACC/3.**
[43] **APP/4.**
[44] **ACC/3.**
[45] Appendix 4 to **APP/4.**

investigation into sea trout stock status and the need for any remedial management action.

Table 1 *Risk Status Categories*

Status	Category	Score
Trend in CPUE significantly up or stable & current stock >80% of reference period	Not at risk	4
Trend in CPUE stable & current stock between 50 and 80% of reference period	Probably not at risk	3
Trend in CPUE stable & current stock <50% of reference period	Probably at risk	2
Trend in CPUE significantly down & current stock <50% of reference period	At risk	1

4.8 A weakness with this method is that the shifting 10-year reference period built into the assessment approach will not necessarily reflect a biological optimum e.g. the maximum number of fish we can expect a catchment to support or 'carrying capacity', and could, for example, in a prolonged period of low stock levels/poor fishery performance result in a favourable assessment of stocks well below carrying capacity.

Stock-recruitment based assessment

4.9 As described above, the starting point in this assessment is the generation of rod catch derived estimates of run and egg deposition - procedures which mirror those well established in assessing the status of salmon stocks in E&W (e.g. applying assumed angling exploitation rates to catch data to derive run estimates, etc.)[46]

4.10 Resulting run and egg deposition estimates are then used to generate time-series of stock and recruitment data to which Ricker stock and recruitment relationships are fitted using non-linear regression methods. In this process, the 'stock' variable is defined as the number of eggs laid in any one year and the 'recruit' variable as the number of whitling (or .0+ fish) that arise from those eggs three years later (calculated on the basis that the great majority of sea trout from rivers in E&W appear to emigrate as 2-year old smolts).

4.11 Whitling abundance is used as an indicator of recruitment because (as a sea age group) they:

[46] This procedure is summarised in Appendix 5 to **APP/4**.

(i) dominate the return (>50%) on most west coast rivers and all the main sea trout rivers in Wales

(ii) are readily identified in the catch data on the basis of weight (trapping data from the Welsh Dee indicates that all fish <1.5lbs are likely to be whitling to the virtual exclusion of all other sea age groups).

(iii) are only lightly exploited by net fisheries because mesh dimensions and their small size mean they largely avoid capture (i.e. as an index of recruitment their abundance at return will not be unduly influenced by netting activity).

(iv) are closely associated with the smolt stage – the stage that marks freshwater carrying capacity – as the whitling and smolt stages are separated by just a few months at sea. Consequently, it is likely that a stock and recruitment relationship defined in terms of whitling recruitment will be similar in form to the equivalent relationship for smolt recruitment, as will the values of associated stock related BRPs.

4.12 The Ricker stock and recruitment relationship derived for the Teifi is shown as an example in Figure 10, with the reference point considered equivalent to maximum smolt output ('Max Smolt') identified at the top of the fitted stock and recruitment curve. This relationship has been fitted to stock and recruitment data sets generated from rod catch returns for the years 1994-2015 (the period since the introduction of the national catch-return and reminder system).

Figure 10 *Sea trout Ricker stock-recruitment curve for the River Teifi (year classes 1995-2013).*

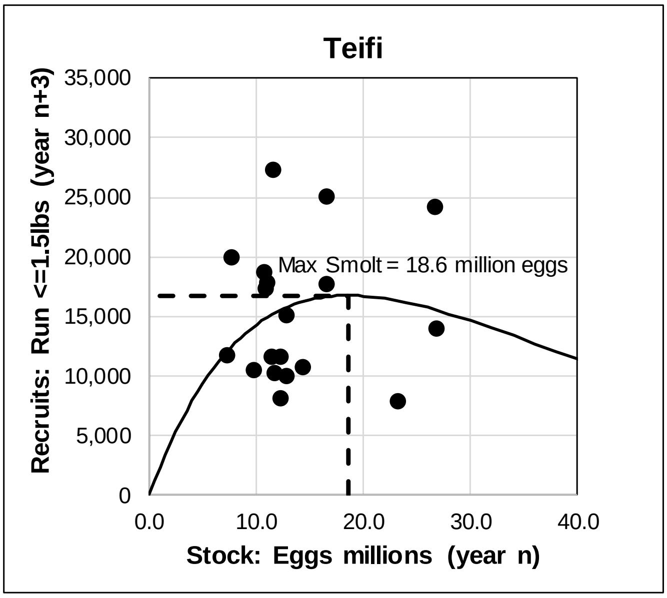
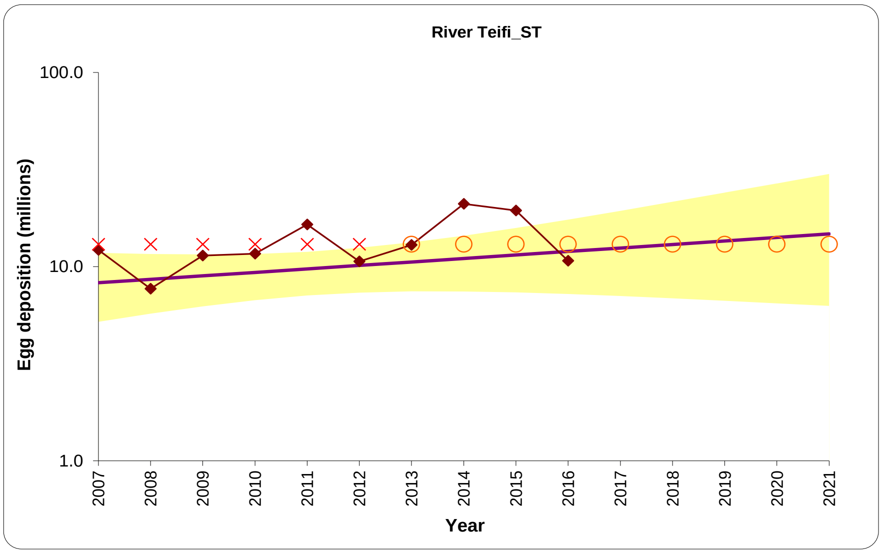


Figure 11 *Compliance with Conservation Limits: Example graphical assessment for Teifi sea trout, 2016*



4.13 In the case of salmon, the Conservation Limit is set at a point termed 'Maximum Sustainable Yield' - someway below Max Smolt. For the stock and recruitment curves derived for sea trout, the equivalent point to the Conservation Limits on the stock axis (based on observations from stock and recruitment curves and reference points for salmon) would occur at around 70% of Max Smolt; this equates to c13.0 million eggs in the Teifi example.

4.14 An indicative Management Target (reflecting the Management Objective that stocks should be at or above the Conservation Limits four years out of five) can be calculated from the Conservation Limits by taking into account year-to-year variation in estimates of egg deposition. The resulting Management Target value in the case of the Teifi is c16.5 million eggs.

4.15 Compliance assessment using the same statistical trend procedure applied to salmon classifies the Teifi as 'probably at risk' in 2016 and (just) 'probably not at risk' in 2021 (Figure 11).

4.16 A key weakness of the fishery-based CPUE assessment for sea trout is that the shifting 10-year reference period built into this approach may not reflect a biological optimum e.g. carrying capacity, and could, in a prolonged period of low stock levels/poor fishery performance result in a favourable assessment of stocks well below carrying capacity (i.e. it has the potential to be under precautionary). The 'risk' classification associated with this assessment, while mimicking that used in salmon Conservation Limits compliance, has no comparable meaning and provides no biological information which might help determine appropriate remedial measures.

4.17 In contrast to the above, the stock-based assessment for sea trout defines, in the Conservation Limit, a reference point with biological meaning. Procedures used to derive the Conservation Limit and assess compliance are similar or identical to those used in salmon. That includes use of the same 'risk' classification along with the facility - through the identification of average spawner or egg shortfalls – to better target regulatory action. In addition, use of a new (sea trout) assessment procedure directly comparable to the equivalent and well established procedure used on salmon also helps promote (through familiarity) understanding among external fishery interests.

Compliance with Conservation Limits: 2017 assessment

4.18 Conservation Limit compliance results for both salmon and sea trout in 2017 – one year on from the assessment which informed the Technical Case - are provided in the attached assessment reports circulated to Local Fisheries Groups in summer 2018[47].

4.19 Moreover, Tables 2 and 3 (below) use results from the 2017 assessment to identify the likely vulnerability of stocks and requirement for additional regulatory measures. These replicate the equivalent Tables from the 2016 assessment given in the Technical Case[48]. The rivers in Tables 2 and 3 are ranked firstly by the projected 'risk' status in 5-years' time (the key statistic in the Decision Structure); then by the direction and severity of trend in the latest 10-year series of egg deposition estimates; and finally by the % egg shortfall against the Management Target (based on average performance over the latest 5-year period).

4.20 Finally, Tables 4 and 5 compare for salmon and sea trout projected compliance status (in five years' time) from the latest (2017) assessment with the equivalent results from previous assessments (2013-2016). As indicated above, projected compliance

[47] **ACC/31** and **ACC/32.**
[48] **APP/4.**

status is the key statistic used to inform the need for management intervention via the Decision Structure.

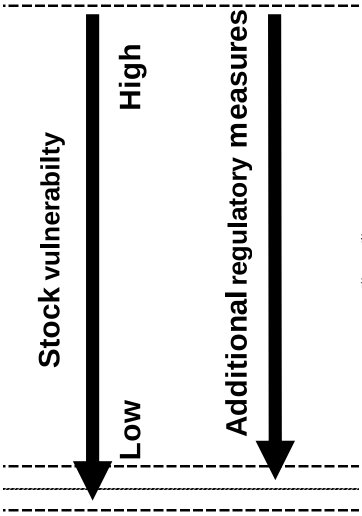
4.21 For salmon there is little change in the pattern of projected risk status between the latest (2017) assessment year and 2016 (the assessment year referred to in the Technical Case) - see Table 4. The exceptions are an improvement in risk class on the Dyfi ('at risk' to 'probably at risk') and a decline in risk status on the Dwyfawr ('probably at risk' to 'at risk) (Table 4).

4.22 Extending this comparison back to the 2015, 2014 and 2013 assessments it is clear that, in all these years, the great majority of rivers in Wales have been classified as either 'at risk' or 'probably at risk', with, in any one year, only 2 or 3 rivers achieving the more favourable classification of 'probably not at risk' (and none considered 'not at risk').

4.23 For sea trout the changes in projected risk status between 2016 and 2017 are more extensive - with fewer rivers in the 'at risk' class in the 2017 assessment than in the 2016 assessment (7 compared to 10), but more in the 'probably at risk' class (16 compared to 7). (Table 5). Six rivers have seen an improvement in risk status, of which three have moved into 'probably not at risk' (Severn and Artro) or 'not at risk' classes (Ogwen). The remainder (Rhymney, Aeron and Ystwyth) are all now classed as 'probably at risk'

Table 2 *Overview of salmon stock status and the requirement for additional regulatory measures following the 2017 assessment*

River	Risk' status: 2022	Trend	Egg deficit/surplus on Management Target (%)
Rheidol	At risk	- - -	-80.40
Clwyd	At risk	- - -	-87.03
Seiont	At risk	- - -	-81.99
Tawe	At risk	- - -	-77.65
Dee	At risk	- - -	-33.65
Dwyfawr	At risk	- -	-86.18
Ogmore	At risk	- -	-78.27
E&W Cleddau#	At risk	- -	-68.11
Dyfi#	Prob at risk	- -	-76.22
Taf#	Prob at risk	- -	-66.01
Teifi#	Prob at risk	- -	-48.66
Glaslyn#	Prob at risk	- -	-15.78
Dwyryd#	Prob at risk	-	-56.47
Tywi#	Prob at risk	-	-48.22
Ogwen	Prob at risk	-	-42.31
Mawddach#	Prob at risk	-	-27.34
Conwy#	Prob at risk	-	-26.92
Dysinni#	Prob at risk	+	-87.29
Taff & Ely	Prob at risk	+	-77.40
Nevern#	Prob at risk	++	-23.33
Wye	Prob not at risk	++	-34.61
Usk	Prob not at risk	++	6.83
Severn##	Prob not at risk	++	14.81



Trend:	
p<0.05	---
p<0.10	---
0.10<=p<0.30	--
0.30<=p<0.50	-
0.70=>p>0.50	+
0.90=>p>0.70	++
p>0.90	+++
p>0.95	+++

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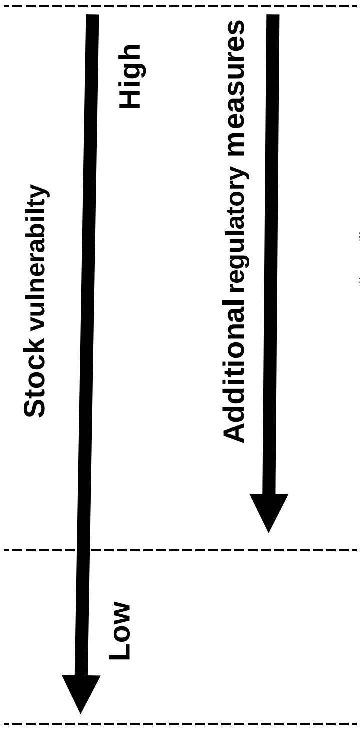
Table 3 *Overview of sea trout stock status and the requirement for additional regulatory measures following the 2017 assessment*

River	Risk' status: 2022	Trend	Egg deficit/surplus on Management Target (%)
Taf#	At risk	- - -	-63.26
Taff & Ely	At risk	- -	-91.31
Gwendraeth	At risk	- -	-77.89
Usk	At risk	- -	-77.27
Tawe	At risk	- -	-71.66
Loughor	At risk	- -	-61.97
E&W Cleddau#	At risk	- -	-52.51
Rhymney	Prob at risk	- -	-85.47
Ystwyth	Prob at risk	- -	-26.26
Neath	Prob at risk	- -	-9.55
Afan	Prob at risk	- -	-5.20
Dwyryd#	Prob at risk	-	-51.93
Wye	Prob at risk	-	-27.50
Tywi#	Prob at risk	-	-22.34
Glaslyn#	Prob at risk	-	-19.25
Nevern#	Prob at risk	-	9.32
Aeron	Prob at risk	+	-55.10
Llyfni	Prob at risk	+	-41.99
Dwyfawr	Prob at risk	+	-17.85
Teifi#	Prob at risk	+	-7.59
Ogmore	Prob at risk	+	-3.92
Clwyd	Prob at risk	++	-28.94
Rheidol	Prob at risk	++	-8.25
Gwyrfai	Prob not at risk	+	-14.11
Artro	Prob not at risk	+	-11.82
Dee	Prob not at risk	+	0.84
Severn##	Prob not at risk	+	5.28
Dysinni#	Prob not at risk	+	19.84
Mawddach#	Prob not at risk	+	54.27
Dyfi#	Prob not at risk	++	31.08
Seiont	Prob not at risk	++	-18.21
Conwy#	Prob not at risk	++	43.87
Ogwen	Not at risk	+++	16.28



Trend:	
p<0.05	---
p<0.10	---
0.10<=p<0.30	--
0.30<=p<0.50	-
0.70=>p>0.50	+
0.90=>p>0.70	++
p>0.90	+++
p>0.95	+++

Review of Net Limitation Order 2017

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Table 4 *Salmon Conservation Limit compliance on Welsh rivers: Projected 'risk' status in 5-years' time for the assessment years 2013-2017*

Assessment year:	**2013**	**2014**	**2015**	**2016**	**2017**
Compliance year:	**2018**	**2019**	**2020**	**2021**	**2022**
No. River					
28 Severn	Prob at risk	Prob at risk	Prob not at risk	Prob not at risk	Prob not at risk
43 Wye	Prob at risk	Prob at risk	Prob not at risk	Prob not at risk	Prob not at risk
44 Usk	Prob at risk	Prob at risk	Prob at risk	Prob not at risk	Prob not at risk
45 Taff & Ely	Prob at risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
46 Ogmore	At risk	Prob at risk	Prob at risk	At risk	At risk
47 Tawe	At risk	At risk	At risk	At risk	At risk
48 Tywi	Prob at risk	At risk	Prob at risk	Prob at risk	Prob at risk
49 Taf	At risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
50 E&W Cleddau	At risk	Prob at risk	Prob at risk	At risk	At risk
51 Teifi	Prob at risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
52 Rheidol	At risk	Prob at risk	Prob at risk	At risk	At risk
53 Nevern	At risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
54 Dyfi	At risk	At risk	At risk	At risk	Prob at risk
55 Dysinni	At risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
56 Mawddach	Prob at risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
57 Dwyryd	At risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
58 Glaslyn	Prob not at risk	Prob not at risk	Prob not at risk	Prob at risk	Prob at risk
59 Dwyfawr	At risk	Prob at risk	Prob at risk	Prob at risk	At risk
60 Seiont	At risk	At risk	At risk	At risk	At risk
61 Ogwen	Prob at risk	At risk	Prob at risk	Prob at risk	Prob at risk
62 Conwy	Prob not at risk	Prob at risk	Prob at risk	Prob at risk	Prob at risk
63 Clwyd	Prob at risk	Prob at risk	At risk	At risk	At risk
64 Dee	At risk	Prob at risk	At risk	At risk	At risk

Table 5 *Sea trout Conservation Limit compliance on Welsh rivers: Projected 'risk' status in 5-years' time for the assessment years 2016-2017*

Assessment year:	**2016**	**2017**
Compliance year:	**2021**	**2022**
No. River		
32 Severn	Prob at risk	Prob not at risk
33 Wye	Prob not at risk	Prob at risk
34 Usk	At risk	At risk
35 Rhymney	At risk	Prob at risk
36 Taff & Ely	At risk	At risk
37 Ogmore	Prob not at risk	Prob at risk
38 Afan	Prob at risk	Prob at risk
39 Neath	Prob at risk	Prob at risk
40 Tawe	At risk	At risk
41 Loughor	At risk	At risk
42 Gwendraeth	At risk	At risk
43 Tywi	Prob at risk	Prob at risk
44 Taf	At risk	At risk
45 E&W Cleddau	At risk	At risk
46 Nevern	Prob not at risk	Prob at risk
47 Teifi	Prob not at risk	Prob at risk
48 Aeron	At risk	Prob at risk
49 Ystwyth	At risk	Prob at risk
50 Rheidol	Prob not at risk	Prob at risk
51 Dyfi	Not at risk	Prob not at risk
52 Dysinni	Not at risk	Prob not at risk
53 Mawddach	Not at risk	Prob not at risk
54 Artro	Prob at risk	Prob not at risk
55 Dwyryd	Prob at risk	Prob at risk
56 Glaslyn	Prob at risk	Prob at risk
57 Dwyfawr	Prob not at risk	Prob at risk
58 Llyfni	Prob not at risk	Prob at risk
59 Gwyrfai	Prob not at risk	Prob not at risk
60 Seiont	Prob not at risk	Prob not at risk
61 Ogwen	Prob not at risk	Not at risk
62 Conwy	Not at risk	Prob not at risk
63 Clwyd	Prob not at risk	Prob at risk
64 Dee	Not at risk	Prob not at risk

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5 Justification for All Wales Byelaws

5.1 This statement has examined, for both salmon and sea trout, (i) general patterns and trends in source data sets collected for fisheries assessment purposes in Wales (i.e. net and rod catch statistics; counts of returning adults; and juvenile electrofishing data) and (ii) the results of Conservation Limit compliance assessment (as the primary means by which NRW evaluates the status of its migratory fish stocks and which has greatest bearing on management decision making).

5.2 The evidence in both cases – including assessment of the latest 2017 data sets – is consistent with the conclusion that most salmon and many sea trout stocks in Wales remain in a depleted state, and provides no indication that the protection sought by the proposed byelaws is no longer required.

5.3 For salmon, the great majority of river stocks have been classified in the poorest risk classes ('at risk' and 'probably at risk') following Conservation Limit compliance assessment in (at least) each of the last 5 years. In-line with the Decision Structure, this classification would trigger the need to seek remedial action through management of the fisheries. The All Wales Byelaws are intended to address that need; and the efficacy of these and other interventions (e.g. seeking improve the wider environment on which fish depend) are addressed in the evidence of Mr Gough[49].

5.4 For sea trout, Conservation Limit compliance assessment also indicates that many stocks are in the poorest risk classes. The All Wales byelaws in this case stop short of the full C&R measures recommended for salmon – being mindful of the new Conservation Limit assessment procedures for sea trout which, while considered an improvement on former approaches, are being applied in a more tentative fashion subject to additional scrutiny and possible further development. The rationale for the All Wales Byelaws for sea trout is also addressed in the evidence of Mr Gough[50].

[49] See sections 7 to 9 of **NRW/1.**

[50] See sections 7 and 8 of **NRW/1**.

6 Summary and conclusions

6.1 This statement has examined the evidence base used by NRW to assess the status of salmon and sea trout stocks in Wales – including the latest results for 2017.

6.2 It has described the main types of fisheries monitoring data routinely collected by NRW for assessment purposes ('all Wales' net and rod catch statistics; counts of returning adults on three rivers in Wales; and juvenile electrofishing data) and has briefly examined patterns and trends in these data sets.

6.3 This data indicates that catches of both salmon and sea trout have declined progressively over the last 40 years, and are now at (salmon) or close to (sea trout) the lowest on record.

6.4 A downturn in salmon catches since 2010 is mirrored by salmon counts on the Taff, Teifi and Dee (and is evident on other counted rivers in England). Salmon counts on all three Welsh rivers in 2017 were the lowest recorded and continue a trend in decline which shows little sign of abating.

6.5 Trapping data from the Dee and elsewhere indicates that this downturn has been driven by a sharp decline in the return of grilse. In part this is being compensated for by improved runs of MSW salmon; however, as most of the principal salmon rivers in Wales are grilse dominated this is likely to be a significant causal factor in rivers failing to meet Conservation Limits.

6.6 Electrofishing surveys have identified widespread reductions in the abundance of salmon and trout fry (and to a lesser extent parr) across a number of rivers in Wales in 2016. Similar observations have been made elsewhere, and it is likely that this failure of recruitment was linked to extreme weather conditions in the winter of 2015, as well as to low levels of spawning. Investigations into this event are ongoing, but poor recruitment of the 2016 year class is likely to have consequences for adult returns in 3-5 years' time, particularly on the worst affected rivers (e.g. Usk).

6.7 The use of Conservation Limits as NRW's main approach to the assessment of salmon stocks and (more recently) sea trout stocks in Wales has been described. This includes specific details relating to the latter methodology and why this development – which has strong parallels with the established use of Conservation limits in salmon - is considered an improvement on the previous fishery-based assessment.

6.8 The latest (2017) assessments for Conservation Limit compliance have been examined. These indicate little positive change in the status of salmon or sea trout stocks in 2017 compared to the previous years' assessment (rather deterioration in the status of sea trout stocks on a number of rivers). This, coupled with the overview of catches, counts and juvenile performance outlined above provides a coherent picture of most salmon and many sea trout stocks in Wales remaining in a depleted state, and provides no indication that the protection offered by the proposed byelaws is no longer required.

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.

Ian Davidson

Senior Technical Advisor Salmonids

On behalf of Natural Resources Wales