Annex 4. Salmon stock management system

Conservation Limits and Management Targets

Setting conservation limits

The use of conservation limits (CLs) in England and Wales (E&W) 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. CLs indicate the minimum desirable spawning stock levels, below which stocks should not be allowed to fall. The CL is set at a stock size 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.

Two relationships are required to derive the CLs:

1. a **stock-recruitment curve** – this defines, for the freshwater phase of the life cycle, the relationship between the number of eggs produced by spawning adults (stock) and the number of smolts resulting from those eggs (recruits).
2. a **replacement line** – this converts the number of smolts emigrating from freshwater to surviving adults (or their egg equivalents) as they enter marine homewaters. This relationship requires an estimate of the survival rate at sea.

The model used to derive a stock-recruitment curve for each river assumes that juvenile production is at a 'pristine' level for that river type (i.e. is not affected by adverse water quality, degraded physical habitat, etc.).

Similarly, in deriving the replacement line, marine survival rates for most river stocks were assumed to be equivalent to the rates estimated on UK monitored rivers (such as the North Esk) in the 1960s and 1970s. Default survival values recommended for this purpose were 25% for 1SW salmon and 15% for MSW fish (Environment Agency, 1998). However, that period is thought to be one of high sea survival, and revised default values of 11% for 1SW and 5% for MSW fish, which are more representative of sea survival over the last 20 years, were introduced by the Environment Agency in April 2003 (Environment Agency, 2003b).

These rates have now been applied in calculating CLs for all the 64 rivers with Salmon Action Plans (SAPs) – including the 23 principal salmon rivers in Wales. Since 2003, the CLs for all principal salmon rivers for which egg deposition estimates are assessed annually have incorporated the new lower marine survival estimates. The net effect of these changes was to reduce the CLs: the scale varied from river to river, but resulted in a 26% reduction, on average, in England and Wales from values used prior to 2003. Introducing marine survival rates which are intended to be closer to those currently experienced by UK salmon stocks will reduce the effect of high mortality at sea as a cause of failing CLs. This will help managers focus on other issues over which they have more control (e.g. poor environmental quality in-river, over-exploitation by net and rod fisheries, etc.) when compliance failure occurs. The reduction in CLs means, however, that lower levels of spawning escapement are accepted before the stock is considered to be threatened. Natural Resources Wales and the Environment Agency also use the 'management objective' for each river (e.g. in reviewing management actions and regulations) that the stock should be meeting or exceeding its CL in at

least four years out of five, on average. This management objective is built into statistical procedures for assessing compliance with CLs (below).

Estimating spawner / egg numbers

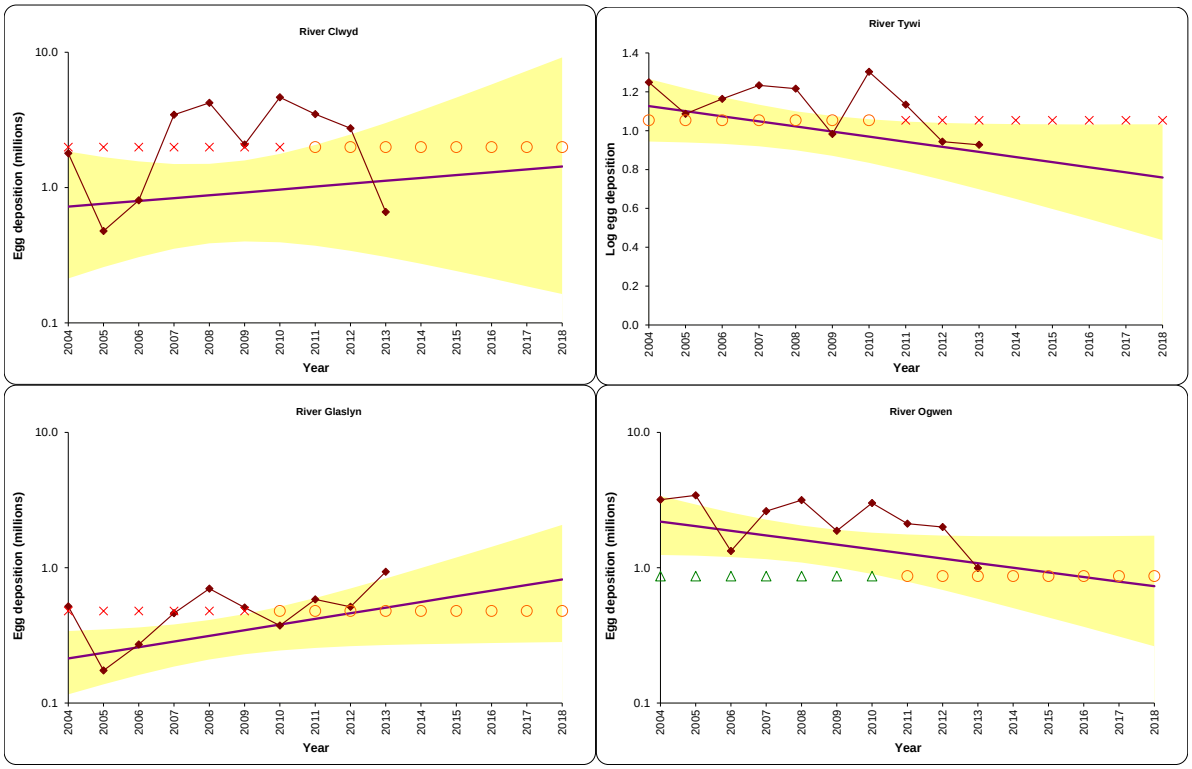
Annual compliance with the CL is assessed using **egg deposition estimates**. On rivers with counters or traps (for example the Dee and Taff in Wales), these are derived from direct measures of the returning stock. However, on the great majority of rivers, the usual procedure for estimating egg deposition involves derivation of run size from rod catch using estimates of exploitation (with adjustment for catch reporting). Other information is also used in estimating egg deposition, for example on the sea age and size composition of the stock and the contribution of rod released fish to the spawning population.

Currently, procedures used to estimate angling exploitation rate do not (in most cases) take into account annual changes in fishing effort. In years when effort was low - such as the 'low-flow' year of 2003 and the 'foot-and-mouth' disease year of 2001 - this approach has probably resulted in rod exploitation being over-estimated on a number of rivers and hence escapement and egg deposition being under-estimated. In wetter years, when conditions are more favourable for angling, and fishing effort increases, the opposite is likely to be true. Work to refine these procedures is ongoing – for example to take account of annual changes in fishing effort, as well as partition effort between salmon and sea trout (no distinction is currently made between these species when reporting fishing effort).

Compliance assessment

The performance of salmon stocks in England and Wales is assessed using a compliance scheme designed to give an early warning that a river has fallen below its CL. 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 CL. Bayesian regression analyses are applied to egg deposition estimates from the last 10 years, on the assumption that there might be an underlying linear trend over the period. The 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 four years out of five (the management objective). If there is a low probability (< 5%) that the 20 percentile regression line is above the CL, 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' ($50\% \leq p < 95\%$)). The results are in broad agreement with the previous compliance scheme used prior to 2004. 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 CL, and so assess the likely effect of recent management intervention and the need for additional measures.

The compliance plots for the rivers Clywd, Tywi, Glaslyn and Ogwen, for the years 2004-2013 are shown below as examples. These include individual egg deposition estimates (solid dots) for these years, the 20 percentile regression lines and (shaded) 90% confidence intervals, and the CL lines (represented by up to three symbols: X, O and Δ).



When the upper bound (95 percentile) of the regression line confidence interval is below the CL line the river is judged to be failing its CL (i.e. there is a ≥95% probability of failure or the river is 'at risk'). For example, this is the case on the Tywi from 2011 to 2018, the Clwyd from 2004 to 2010 and the Glaslyn from 2004 to 2009 and is indicated by the X symbol on the CL line. When the lower bound (5 percentile) of the regression line confidence interval is above the CL line the river is judged to be passing its CL (i.e. there is a ≤5% probability of failure and the river is 'not at risk'). This is the case on the Ogwen from 2004 to 2010 and is indicated by the Δ symbol on the CL line. For all other years on these rivers, the shaded confidence interval of the regression line overlaps the CL 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, for a period, on all four rivers shown above and is indicated by the O symbol on the CL line. In these cases, for the years when the O symbol is present and the regression line is above the CL line the river is classed as 'probably not at risk'; similarly when the opposite applies – i.e. the regression line is below the CL line, then the river is classed as 'probably at risk'.

Egg deposition estimates for a river may be consistently above the CL but status may still be uncertain. This is the case on the Ogwen from 2011 onward (O symbol on the CL line). In part, this reflects the marked year-to-year variation in egg deposition estimates on these rivers, which produces a broad confidence interval 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.

As well as providing an assessment of the status of a river in relation to its CL, 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.

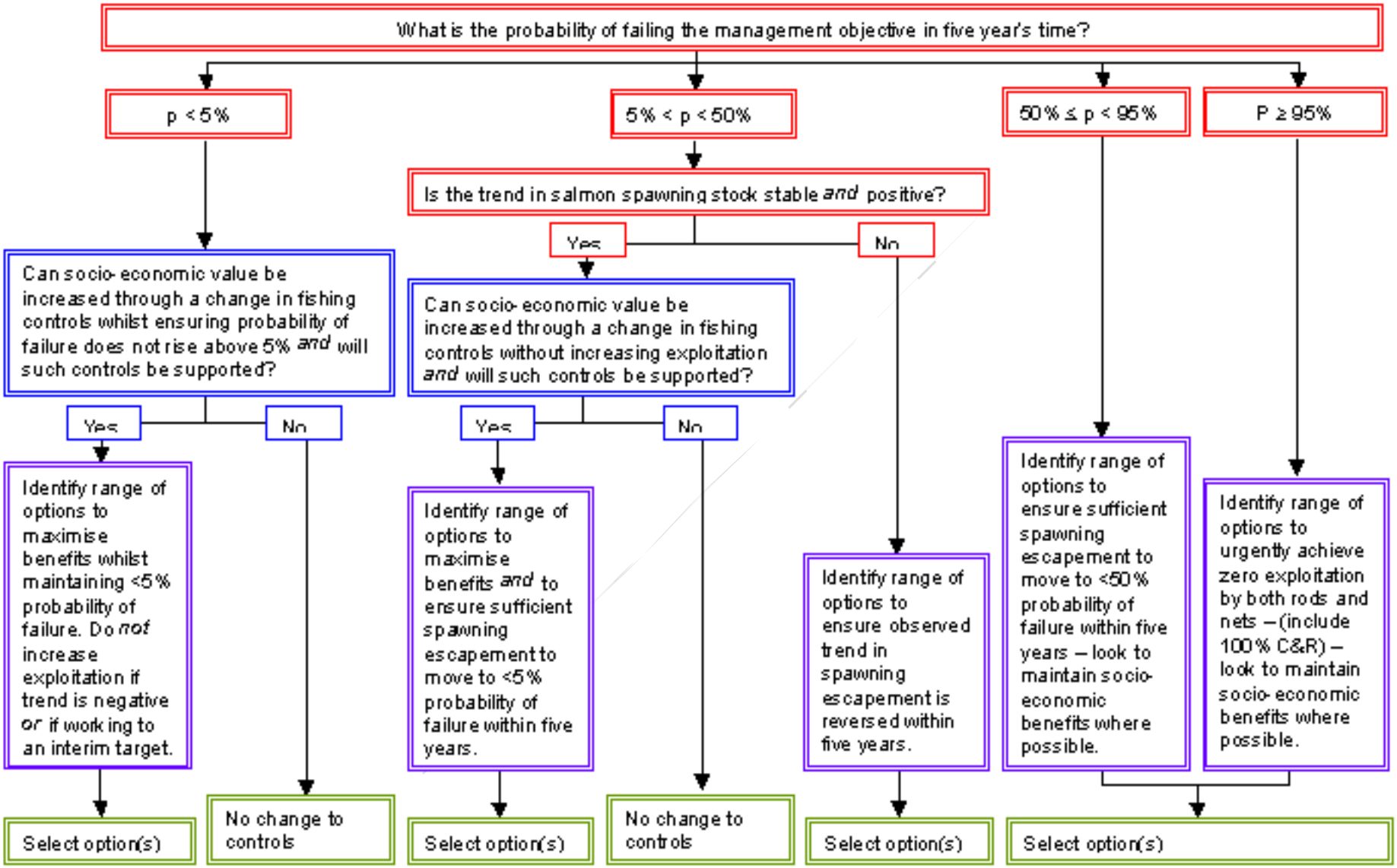
The **Management Target** (MT) for each river is a spawning stock level for managers to aim at, to ensure that the objective of exceeding the CL is met four years out of five in the long run (i.e. 80% of the time). The value of the MT has been estimated using the standard deviation (SD) of egg deposition 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 CL forms the 20 percentile of a distribution, the average (or 50 percentile) of which equates to the MT.

CLs and MTs 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 CL does not mean that there will be no need for any management action. Similarly, the fact that a stock may fall below its CL for a small proportion of the time may not mean there is a problem. Thus, a range of other factors are 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 and the production of juveniles in the river sub-catchments. These data are provided by a programme of river catchment monitoring.

Natural Resources Wales and the Environment Agency are continuing to review and revise their procedures for using reference points and other modelling techniques in the assessment and management of salmon stocks. Work is underway to better reflect real exploitation rates, where these are available, in stock assessments, and to review the balance between use of default (generic) and river-specific data. The assessment approach described above is now incorporated into the national decision structure (see below) for guiding decisions on fishery regulations.

<u>The Decision Structure for developing fishing controls in England and Wales</u>

The compliance assessment approach described above for determining the performance of each salmon river is also incorporated into a national (E&W) decision structure for guiding decisions on the need for fishery regulations. The ‘Decision Structure’ is shown in the schematic flow chart below, together with explanatory notes for its use.


What is the probability of failing the management objective in five year's time?
p < 5%
5% < p < 50%
50% ≤ p < 95%
P ≥ 95%
Is the trend in salmon spawning stock stable and positive?
Yes
No
Can socio-economic value be increased through a change in fishing controls whilst ensuring probability of failure does not rise above 5% and will such controls be supported?
Yes
No
Identify range of options to maximise benefits whilst maintaining <5% probability of failure. Do not increase exploitation if trend is negative or if working to an interim target.
Select option(s)
No change to controls
Can socio-economic value be increased through a change in fishing controls without increasing exploitation and will such controls be supported?
Yes
No
Identify range of options to maximise benefits and to ensure sufficient spawning escapement to move to <5% probability of failure within five years.
Select option(s)
No change to controls
Identify range of options to ensure observed trend in spawning escapement is reversed within five years.
Select option(s)
Identify range of options to ensure sufficient spawning escapement to move to <50% probability of failure within five years – look to maintain socio-economic benefits where possible.
Identify range of options to urgently achieve zero exploitation by both rods and nets – (include 100% C&R) – look to maintain socio-economic benefits where possible.
Select option(s)

1. Initial stage – stock assessment (red boxes)
This is the assessment of the probability that the salmon river will be meeting its CL four years out of five (the management objective) in five years' time, with the latest results available in the most recent annual assessment report for E&W:

https://www.gov.uk/government/publications/salmon-stocks-and-fisheries-in-england-and-wales-in-2015

and

https://www.gov.uk/government/publications/assessment-of-salmon-stocks-and-fisheries-in-england-and-wales).

2. Second stage – initial screening for potential options (blue boxes)
This stage screens options appropriate to those rivers that have a **<50% probability of failing the management objective** taking into consideration socio-economic concerns and stakeholder support. Management options that would not be supported by stakeholders can be ruled out. One of the possible options is to 'do nothing'.

For rivers where there is **>50% probability of failing the management objective**, all options must be carried through to the next (evaluation) stage.

3. Third stage – option evaluation (purple boxes)
The purpose of this stage is to set out and evaluate options to realise the required changes in exploitation.

For rivers where 50% ≤ p < 95% (where p= probability of failing the management objective) **and the trend is down** and with an annual catch of >20 salmon and C&R rate < 90%, then voluntary catch and release (C&R) will be promoted for 1 year. If this fails to significantly improve C&R rates, mandatory C&R or closure of the fishery will be considered. Protected rivers such as SACs (Special Areas of Conservation) are given particular emphasis.

For rivers where the above criteria apply, except that the annual mean salmon catch is <20 salmon, voluntary measures will be promoted.

For rivers where p>95% (i.e. the management objective is clearly being failed) and with an annual catch of >20 salmon and a C&R rate < 90%, then voluntary C&R will be promoted for 1 year. If this fails to significantly improve C&R, mandatory C&R or closure of the fishery will be considered.

For rivers where p ≤ 95% for 5 consecutive years (i.e. the management objective is clearly being met), the possibility of relaxing controls including on nets will be considered if stakeholders agree.

Rivers that are recovering from historical degradation that do not yet have CLs set, are deemed to have a >95% probability that they are failing unless there is better information available. Fishers on such rivers are encouraged to practice 100% C&R

at the same time as regulators and partner organisations work on the necessary environmental improvements. If the potential for these rivers is greater than an average rod catch of 20 salmon, then mandatory C&R is considered throughout the season as an interim measure. However, controlled development of fisheries may be permitted on these rivers in parallel with the recovery of stocks.

4. Final stage – selection and implementation (green boxes)
The final stage of the Decision Structure is the selection and implementation of the appropriate regulatory action.

References Annex I (NB – not attached here):
Environment Agency, 1998. Salmon action plan guidelines version 1, Environment Agency.
Environment Agency, 2003(b). Salmon action plan guidelines, version 2, Environment Agency, April 2003.