Department for Environment Food & Rural Affairs

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# Report to the European Commission in line with Article 9 of the Eel Regulation 1100/2007

## Implementation of UK Eel Management Plans

**June 2015**

Llywodraeth Cymru
Welsh Government

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UK EMP Progress Report 2015



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## Contents

# Executive summary

This report outlines the monitoring, effectiveness and outcome of the Eel Management Plans (EMPs) implemented within the 14 UK River Basin Districts (RBDs). This is in accordance with Article 9 of Regulation No 1100/2007. The transboundary EMP shared with the Republic of Ireland (North West International) is not reported here because it is included in the report of the Republic.

Three of the 14 RBDs are presently assessed as meeting or exceeding their eel management targets.

A range of management measures have been implemented to increase and/or protect silver eel production across the UK. In summary, these measures include restrictions on fisheries ranging from changes in quotas and close seasons to outright bans, the stocking of glass eels, provision of additional eel habitat via removal of barriers to upstream migration, and entrainment reduction measures such as screening and “trap and transport”.

It is not yet possible to predict whether and when these measures will achieve the required additional silver eel production across the UK. Therefore, it is not yet possible to predict when the UK will meet its targets across all RBDs. Investment in scientific research continues, including further development of the assessment method for England and Wales to allow assessments to be reported with associated levels of uncertainty, alongside implementation of management measures to address anthropogenic impacts.

EMPs and assessment procedures vary according to different management structures in England, Wales, Scotland and Northern Ireland. Data are tabulated and described for all 14 EMPs together where appropriate, but in some circumstances where methods differ, data are tabulated and described separately for each region.

The remainder of this report is structured in accordance with the layout of the draft “Guidance Document for the production of Reports to be submitted in line with Article 9 of the Eel Regulation 1100/2007” (hereafter, the Guidance 2015).

Tables 2 to 4 summarise the best available estimates of silver eel escapement biomass, mortality rates due to fisheries and other anthropogenic factors, and quantities of glass eel used for stocking for the 14 RBDs of the UK during the most recent three-year period of the EMPs (2011 to 2013 or 2012 to 2014, depending on jurisdiction). The complete time-series of required data are provided in the accompanying electronic tables “UK 2015 EMP Progress Report tables.xlsx”.

# 1. Introduction

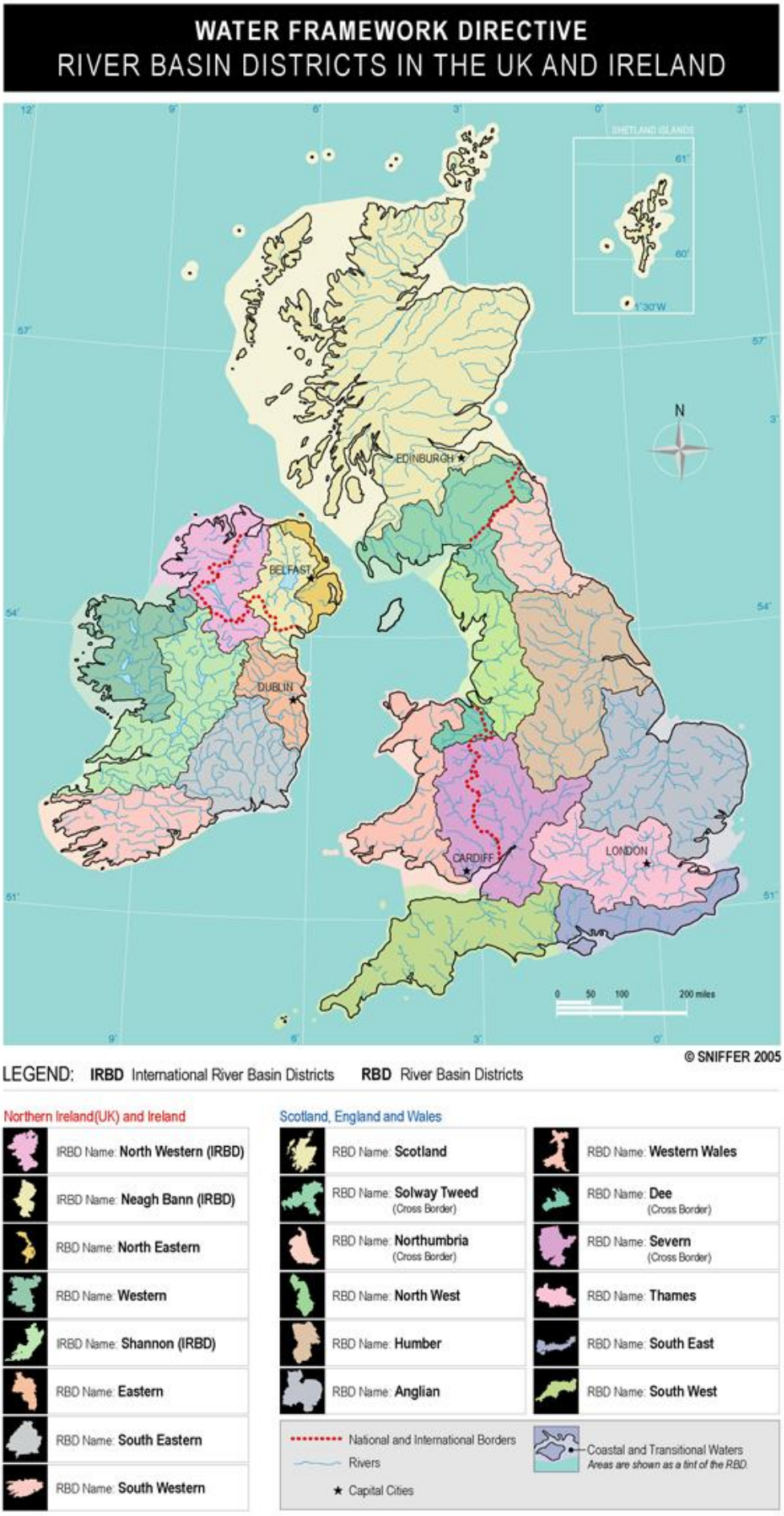
## 1.1 The UK EMP framework

This report outlines the monitoring, effectiveness and outcome of the UK EMPs during the most recent three-year reporting period. This is in accordance with Article 9 of Regulation No 1100/2007. The remainder of this report is structured in accordance with the layout of the draft "Guidance Document for the production of Reports to be submitted in line with Article 9 of the Eel Regulation 1100/2007" (hereafter, the Guidance 2015).

The 14 UK Eel Management Plans (EMPs) are set at the River Basin District (RBD) level, as defined under the Water Framework Directive 2000/60/EC, covering England, Wales, Scotland and Northern Ireland (Figure 1). The RBDs in Northern Ireland deviate slightly from those defined for the WFD, owing to their transboundary nature: the North West International plan is a transboundary plan with the Republic of Ireland; its assessment and management are the responsibility of the Marine Institute in Ireland, and progress with this plan is therefore reported in the Irish Progress Report.

Fisheries management is a devolved policy area in the UK and as such Eel Management Plans were drawn up by the relevant UK authorities within each of the devolved administrations: the Environment Agency (for England and Wales at the time the EMPs were drafted); the Scottish Executive; Department of Culture, Arts & Leisure; and assessed by the appropriate scientific agencies. The implementation of EMPs is managed by different regional agencies: the Environment Agency for England; Natural Resources Wales (NRW) for Wales; Marine Scotland Science (MSS) for Scotland; and the Agri-Food and Biosciences Institute (AFBINI) for Northern Ireland.

*Figure 1. Schematic map of the River Basin District (RBD) layout across the UK, which forms the basis of the associated Eel Management Plans (EMPs).*


WATER FRAMEWORK DIRECTIVE
RIVER BASIN DISTRICTS IN THE UK AND IRELAND
SHETLAND ISLANDS
EDINBURGH
BELFAST
DUBLIN
CARDIFF
LONDON
N
0 50 100 200 miles
© SNIFFER 2005
LEGEND: IRBD International River Basin Districts RBD River Basin Districts
Northern Ireland(UK) and Ireland
IRBD Name: North Western (IRBD)
IRBD Name: Neagh Bann (IRBD)
RBD Name: North Eastern
RBD Name: Western
IRBD Name: Shannon (IRBD)
RBD Name: Eastern
RBD Name: South Eastern
RBD Name: South Western
Scotland, England and Wales
RBD Name: Scotland
RBD Name: Solway Tweed (Cross Border)
RBD Name: Northumbria (Cross Border)
RBD Name: North West
RBD Name: Humber
RBD Name: Anglian
RBD Name: Western Wales
RBD Name: Dee (Cross Border)
RBD Name: Severn (Cross Border)
RBD Name: Thames
RBD Name: South East
RBD Name: South West
National and International Borders
Rivers
Capital Cities
Coastal and Transitional Waters
Areas are shown as a tint of the RBD

## 1.2 The assessment stock indicators

Member States are required to report the status of their eel stocks in each EMP in terms of best available estimates of four stock indicators, as follows:

- $B_{current}$: the biomass of the escapement in the current year;
- $B_0$: the biomass of the escapement in the pristine state;
- $B_{best}$: the estimated biomass in the assessment year, based on the recently observed recruitment, but assuming no anthropogenic impacts have occurred;
- ∑A: the lifetime anthropogenic mortality rate. ∑A is the summation of the fishery mortality (∑F) and all other anthropogenic mortalities (∑H). These rates are estimated by converting the eel stage affected to silver eel equivalents and then expressed as a proportion of present-day silver eel escapement.

## 1.3 Reporting format for 2015

The differing management structures within the UK mean that EMPs and assessment procedures vary between England, Wales, Scotland and Northern Ireland (see original EMPs, and information describing updates in assessment methods in Annexes A, B and C of this report). As a consequence, there are some key differences in the manner in which assessments are reported here for the four regions of the UK.

First, although assessments are updated annually for the Scotland and Northern Ireland EMPs, the input data for the EMPs of England and Wales are derived from a six-year rolling programme of surveys and therefore can only be fully updated every six years. For reporting to the three-year cycle of the EC Regulation, however, assessments for England and Wales are updated where new data are available from surveys that have been conducted during that time period.

As a consequence, the underlying assessments of $B_{best}$ across England and Wales are the same for each year within these three -year periods. The small differences reported in $B_{current}$ are due to differences between years in the amount of commercial eel catch. Hence it is unwise to draw conclusions from apparent trends or otherwise within three -year reporting periods, whereas it is more informative to compare average values between three-year reporting periods.

Second, the annual schedule of reporting eel population survey data in England and Wales is such that data for 2014 were not available in time to be included in the assessments to meet the deadline for presentation of the report to the European Commission of 30th June 2015. Therefore, and to retain the three-year reporting schedule, the biomass estimates for England and Wales are reported for 2011, 2012 and 2013, whereas those for 2014 will be reported in the EMP Progress Report in 2018.

Taking these two 'data availability' factors into account, the assessment of emigrating biomass for England and Wales was estimated in three-year blocks:

- 2008-2010
    - Used to assess emigrating biomass and mortality indicators for 2009 and 2010, the first period since the implementation of the EMPs;
- 2011-2013
    - Used to assess emigrating biomass and mortality indicators for 2011, 2012 and 2013.

In contrast, the biomass estimates for Scotland and Northern Ireland are reported here for 2012, 2013 and 2014: as these are updated annually, it is appropriate to consider trends from year to year.

## 1.4 Changes in the assessment method since the 2012 report

**England and Wales**

The current assessment method applied across England and Wales is described in Annex A. There have been a number of significant developments in the method since it was first used to propose targets and assess stock status in the original EMPs (approved 2010). As a consequence of these continued developments (summarised below), the results reported to the Commission in 2012 were revised in the report to the ICES Technical Review in 2013 (ICES, 2013), and the 2015 stock indicators have been recalculated for the reference period (pre-1980s), immediately before, and ever since implementation of the EMPs.

The estimates of $B_{best}$ have been revised by the addition of 33 more index rivers across the 11 RBDs (cf. 11 rivers for 2012 report vs 44 rivers for 2015 report).

Estimates of anthropogenic impacts and hence derivation of $B_{current}$ from $B_{best}$ have been revised by the application of a new analysis quantifying the losses due to barriers to eel migration. These losses were not accounted for in the 2012 or 2013 reports, because the method had not been developed at that time.

The $B_0$ estimates have been revised by the inclusion of the new method to take account of the impact of barriers during the reference period. Table 1 shows how these $B_0$ estimates have changed since those presented in the 2012 Progress Report, and in the 2013 Technical Review.

In the absence of historic data on silver eel production in England and Wales, the management target for silver eel escapement was set in the original EMPs at 40% of

16kg.ha$^{-1}$, i.e. 6.4kg.ha$^{-1}$. This value was selected in reference to comparison with production rates from other Member States with similar eel habitat types as England and Wales, and approved by the EU in 2010. Developments for the 2012 Progress Report led to a revision of $B_0$ to approximately 16.25kg.ha$^{-1}$ based on modelling of the yellow eel population data of the River Dee in 1984. However, it was noted in the 2012 Progress Report that "Pristine production from other RBDs is likely to differ from that of the Dee, because of local and regional variations (e.g. recruitment to east coast rivers would be expected to be lower). Therefore, $B_0$ and the 40% target are likely to be revised as and when local data become available." Data for additional rivers modelled using the same method in late 2012 and early 2013 resulted in revised $B_0$ estimates for each RBD, and the additional accounting of the effects of barriers has meant that the $B_0$ estimates have been further revised.

In the interpretation of these assessments it needs to be noted that confidence in the $B_0$ and $B_{current}$ values is low, as outlined in Annex A. Work continues to improve the assessment method, including model developments to enable estimates to be reported with associated levels of confidence based on the uncertainties in all input data.

*Table 1. Comparison of $B_0$ estimates (kg.ha$^{-1}$) for RBDs of England and Wales reported during the method development.*

| | Reporting date (not assessment date) | | |
|---|---|---|---|
| RBD | June 2012 | March 2013 | February 2015 |
| Northumbria | 16.25 | 5.98 | 5.16 |
| Humber | 16.25 | 2.73 | 2.38 |
| Anglian | 16.25 | 2.26 | 6.27 |
| Thames | 16.25 | 11.91 | 5.88 |
| South East | 16.25 | 8.56 | 10.60 |
| South West | 16.25 | 19.3 | 37.03 |
| Severn | 16.25 | 6.84 | 11.98 |
| West Wales | 16.25 | 13.98 | 16.18 |
| Dee | 16.25 | 29.89 | 45.02 |
| North West | 16.25 | 13.98 | 18.50 |
| Solway Tweed | 16.25 | 13.37 | 16.84 |

**Scotland**

The method used to estimate stock indicators has also developed in Scotland since the 2012 report (see Annex B), principally by the inclusion of an estimate for eel production in transitional waters, which were previously ignored. Since anthropogenic mortalities in Scottish transitional waters are assumed to be zero, this has led to a substantial decrease

in the estimated mortality rates for the Scottish stock as a whole compared to those in the 2012 report, but has little impact on the 40% target assessment, since pristine conditions estimates for fresh waters are also applied to transitional waters.

**Northern Ireland**

The assessments used to monitor silver eel production and escapement estimates for Northern Ireland have remained the same since the 2012 Report, are provided in Annex C and summarised here below.

For the only RBD in Northern Ireland with a fishery, the Neagh/Bann, the estimate of pristine escapement ($B_0$) was determined using historic data including catch and sex ratio, input-output regression analysis, and from known productivity of eel growing areas (see Section 11.4 of the Neagh/Bann EMP). Using these three methods pointed to a potential natural output in the range of 400 to perhaps 600 tonnes per annum, given historical high natural glass eel supplies. This range would estimate the required 40% level at around 160t to 240t, so mid-point of 200 t was selected.

In addition, an annual mark-recapture programme has been conducted since 2003 (Rosell *et al.,* 2005) and where relevant, data over this extended reporting period have been incorporated into this current report. To date, 6779 eels have been tagged with Floy™ Tags and recaptures recorded at both silver eel fishing sites in the RBD. This work was further enhanced and corroborated by implementing a hydro-acoustic tracking study (a not foreseen, but implemented measure) in 2011.

For the North Eastern RBD, data relating to eel population densities and age distribution gathered for assessment purposes are to be included in an eel production and escapement modelling exercise as agreed and devised by the All-Ireland Standing Scientific Committee on Eel (SSCE). This work is scheduled from March 2015 onwards and therefore does not form part of the current report.

# 2. Best available estimates of stock indicators and associated information

## 2.1. Summary results

Tables 2 to 4 present the best available estimates of silver eel escapement biomass, mortality rates due to fisheries and other anthropogenic factors, and quantities of glass eel used for stocking, for the 14 EMU of the UK during the most recent three-year period of the EMPs: 2011-2013 for England and Wales; 2012-2014 for Scotland and Northern Ireland. The full time series of data are provided in the accompanying electronic tables “UK 2015 EMP Progress Report tables.xlsx”.

## 2.2. Biomass

In 2013, the most recent year for which estimates are available for all EMPs, silver eel escapement exceeded the 40% $B_0$ target in three RBDs: South East, Scotland and Neagh/Bann.

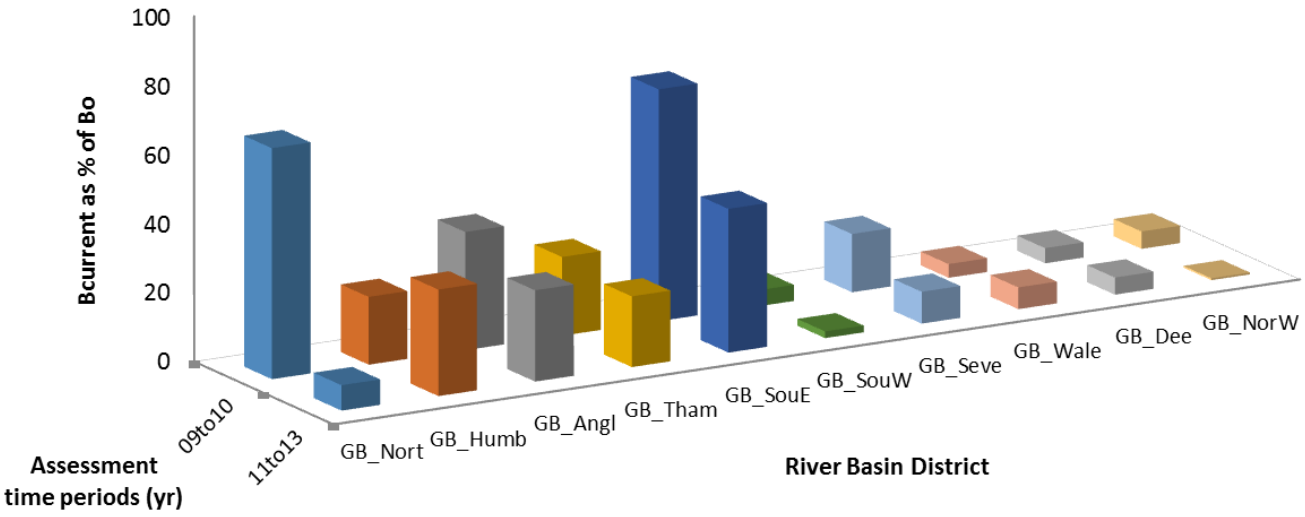
The South East exceeded its target by 2,271kg in 2013. Scotland exceeded its target by 93,508kg per annum, and the Neagh/Bann RBD exceeded its target by 78,853kg per annum, based on estimates for the period 2012 to 2014.

A new method is being implemented to estimate $B_{current}$ and $B_{best}$ for the North Eastern RBD but results were not available for this report, so the status of this RBD is uncertain. However, as there are few if any anthropogenic mortality factors impacting eel in this RBD, its status is considered ‘natural’.

**Trends in biomass**

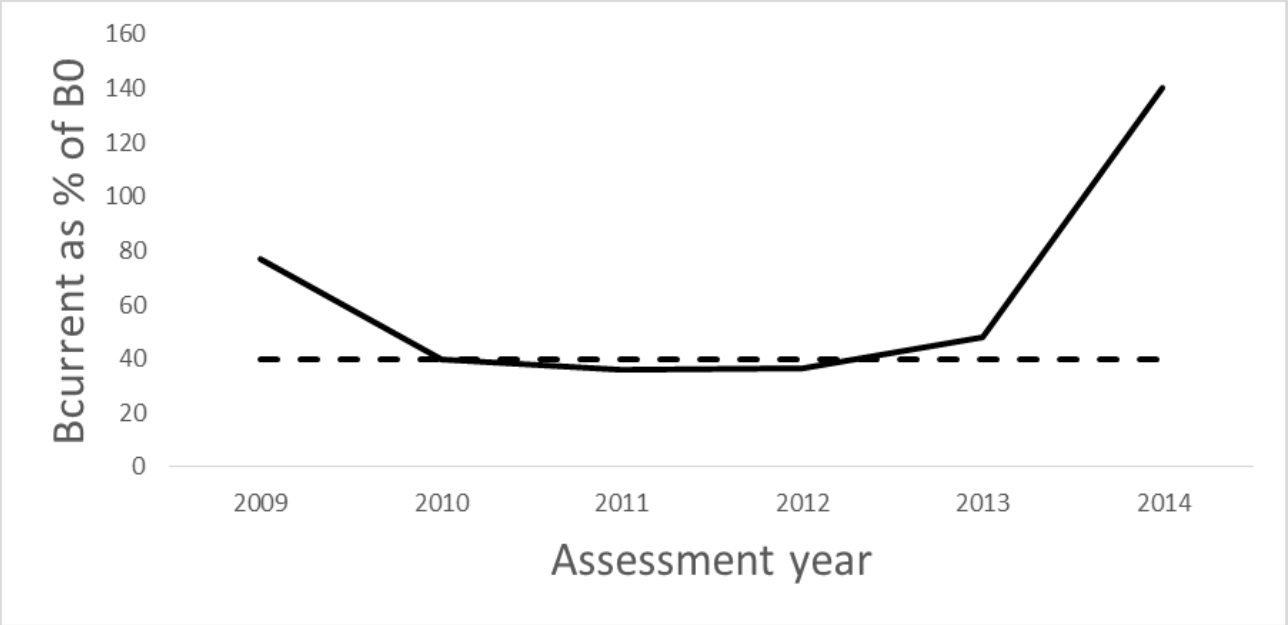
For England and Wales, comparing the average values of silver eel escapement ($B_{current}$) expressed as a percentage of $B_0$ for 2009-2010 versus the average for 2011 to 2013, they have decreased in eight RBDs and increased in three (Figure 2), although only five of these changes could be considered substantial changes (arbitrarily defined as > ± 5% $B_0$).

*Figure 2. Change in $B_{current}$ as a percentage of $B_0$ in RBDs of England and Wales between 2009-2010 and 2011-2013. The solid lines represent the 11 RBDs while the dashed line represents the 40% $B_0$ target level.*




For the Scotland RBD, as the assessment is conducted separately for each year, a fuller trend analysis is appropriate. $B_{current}$ expressed as a percentage of $B_0$ declined from 2009 to 2011 but has since increased, returning above the 40% management target in 2013 and exceeding the $B_0$ level in 2014 (Figure 3). The 2014 $B_{current}$ estimate at 140% of $B_0$ is due to 2014 being an exceptionally good year for silver eel escapement in the Scotland RBD and the $B_0$ reference value being an average of several years of historic data.

*Figure 3. Change in $B_{current}$ as a percentage of $B_0$ in the Scotland RBD of England and Wales between 2009 and 2014. The dashed line represents the 40% $B_0$ target level.*




For the Neagh/Bann RBD in Northern Ireland, $B_{current}$ expressed as a percentage of $B_0$ increased from 2009 to 2012, when it exceeded the target. It has since declined but is still in excess of the target. No biomass estimates are available for the North Eastern RBD at this time.

*Figure 4. Change in $B_{current}$ as a percentage of $B_0$ in the Northern Ireland Neagh/Bann RBD between 2009 and 2014. The dashed line represents the 40% $B_0$ target level.*

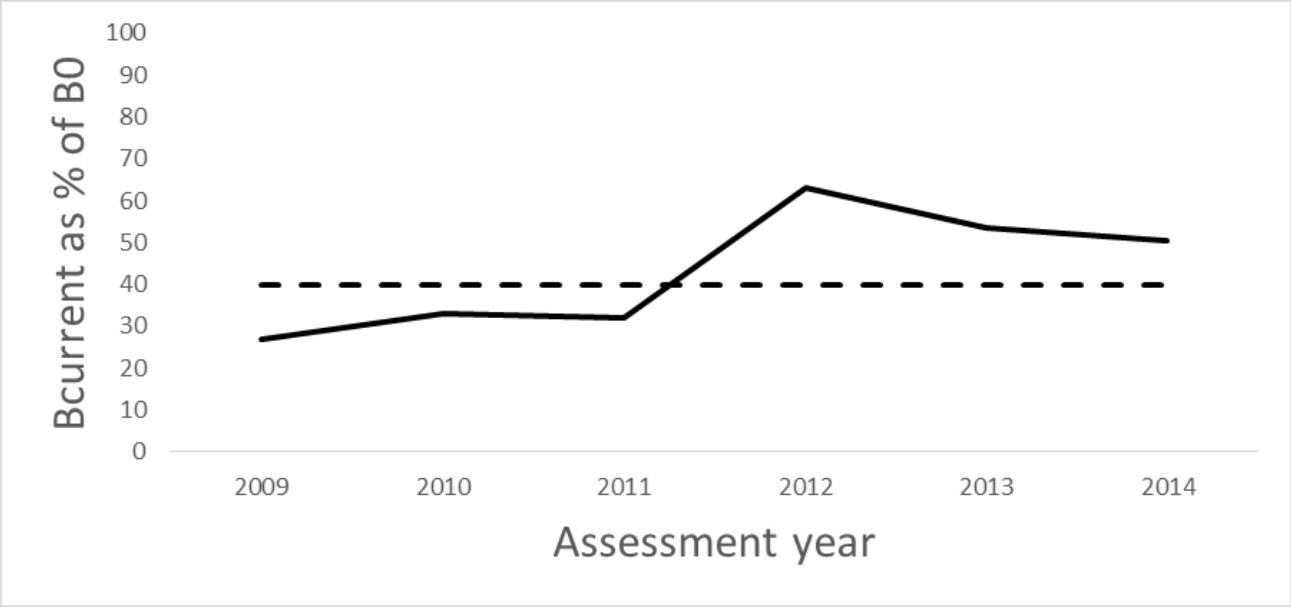


*Table 2. Best estimates of silver eel biomass (kg) across RBDs, during 2011 to 2014.*

| RBD code | $B_0$ | $B_{current}$ | | | | $B_{best}$ | | | | Average compliance (%) in most recent 3 years |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-1980 | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 | |
| Northumbria | 60876 | 4478 | 4478 | 4478 | ND | 9577 | 9577 | 9577 | ND | 7 |
| Humber | 137859 | 42157 | 42377 | 43147 | ND | 137859 | 137859 | 137859 | ND | 31 |
| Anglian | 341084 | 87949 | 88118 | 94596 | ND | 171573 | 171573 | 171573 | ND | 26 |
| Thames | 251699 | 49286 | 53865 | 51581 | ND | 162444 | 162444 | 162444 | ND | 20 |
| South East | 121340 | 50511 | 50318 | 50807 | ND | 75622 | 75622 | 75622 | ND | 42 |
| South West | 1327684 | 28545 | 25906 | 22767 | ND | 170603 | 178185 | 319248 | ND | 2 |
| Severn | 899687 | 82534 | 83264 | 83264 | ND | 235791 | 243276 | 383532 | ND | 9 |
| West Wales | 429944 | 27117 | 26730 | 27277 | ND | 35448 | 35207 | 37231 | ND | 6 |
| Dee | 636166 | 30940 | 31663 | 31958 | ND | 53178 | 53314 | 53223 | ND | 5 |
| North West | 865449 | 4808 | 3121 | 5781 | ND | 25584 | 21188 | 25350 | ND | 1 |
| Solway Tweed | 1473755 | 29925 | 29925 | 29925 | ND | 38885 | 38885 | 38885 | ND | 2 |
| Scotland | 267717 | 96027 | 97623 | 128339 | 375823 | 100362 | 124880 | 158408 | 454241 | 75 |
| North Eastern | 4000 | ND | ND | ND | ND | ND | ND | ND | ND | NC |
| Neagh/Bann | 500000 | 154666 | 315900 | 267600 | 253000 | 582000* | 691900 | 660600 | 611200 | 56 |

**Where:**

- $B_0$ The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.
- $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn.
- $B_{best}$ The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.
- ND "No Data", where there are insufficient data to estimate a derived parameter (for example where there are insufficient data to estimate the stock indicators (biomass and/or mortality)).
- NC "Not Collected", activity / habitat exists but data are not collected by authorities (for example where a fishery exists but the catch data are not collected at the relevant level or at all).
- *The Neagh/Bann Bbest estimate for 2011 derives from an input (recruitment) period of 1992 to 1999 when recorded annual recruitment (stocking and natural) averaged 2068kg glass eel. Fishery management actions include enhancement by assisted migration of recruits and stocking from other RBDs.

## 2.3. Mortality rates

Estimates of annual anthropogenic mortality rates for eel attributed to fishing (ΣF), non-fishing human impacts (ΣH) and both combined (ΣA) are presented for each RBD in Table 3. These rates are estimated by converting the eel stage affected to silver eel equivalents and then expressed as a proportion of present-day silver eel escapement.

There are no recreational landings of eel across the UK. Commercial fishing occurs in nine of the eleven RBDs across England and Wales, and in one RBD in Northern Ireland, but not in Scotland. Comparing 2013 with 2011, the impact (mortality rate) of commercial fishing (ΣF) has increased in three RBDs, decreased in six, and not changed in one.

The increases in England and Wales are due largely to higher catches of glass eel (all three RBDs): catches of yellow and silver eels increased in only one (South West) of the three RBDs (see Tables A3 to A5). The higher glass eel catches are considered to reflect higher levels of abundance in those years, as evidenced by increases in catch per unit effort in the UK fishery, and higher catches or quicker achievement of quota in Spanish and French fisheries, respectively (ICES, 2014).

The impact (mortality rate) of non-fishing anthropogenic factors (ΣH) decreased in three RBDs and showed little change in the others. The estimated impacts of non-fishing anthropogenic mortality factors are disaggregated into those due to (a) entrainment and mortality at water intakes, (b) loss of habitat quantity and quality, (c) stocking (a positive effect and therefore presented as a negative mortality rate), and (d) others, and time series of these estimates are provided in the accompanying electronic tables “UK 2015 EMP Progress Report tables.xlsx”.

The overall impact of anthropogenic mortality factors (ΣA) therefore showed substantial increases in two RBDs (South West and Severn), a substantial decrease in two (North West and Neagh/Bann) and little change in the others.

Stocking is a relatively minor activity in England and Wales, with only 122kg in 2011, 23kg in 2012 and 55kg in 2013 (Table 4), which are predicted to result in 7589kg of silver eel (equivalents) in the fullness of time (note anthropogenic impacts on these eels have not been taken account in these estimates). There has been no eel stocking in Scotland for a number of years.

Eel stocking is important to the Neagh/Bann EMP in Northern Ireland, and 5856kg of glass eels were stocked in Lough Neagh during 2012 to 2014. These glass eels were all sourced from the UK fishery in the Severn Estuary. An additional 20kg, purchased by the Lough Neagh fishery, were stocked into the river Lagan, the main river in the North Eastern RBD.

There is no glass eel fishery in Northern Ireland.

*Table 3. Best estimates of anthropogenic mortality rates across UK RBDs, during 2011 to 2014*

| RBD code | ΣF | | | | ΣH | | | | ΣA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 |
| Northumbria | 0.00 | 0.00 | 0.00 | ND | 0.76 | 0.76 | 0.76 | ND | 0.76 | 0.76 | 0.76 | ND |
| Humber | 0.06 | 0.06 | 0.05 | ND | 1.12 | 1.12 | 1.11 | ND | 1.18 | 1.18 | 1.16 | ND |
| Anglian | 0.15 | 0.15 | 0.09 | ND | 0.52 | 0.52 | 0.50 | ND | 0.67 | 0.67 | 0.60 | ND |
| Thames | 0.07 | 0.02 | 0.04 | ND | 1.12 | 1.08 | 1.10 | ND | 1.19 | 1.10 | 1.15 | ND |
| South East | 0.04 | 0.04 | 0.04 | ND | 0.36 | 0.36 | 0.36 | ND | 0.40 | 0.41 | 0.40 | ND |
| South West | 1.57 | 1.71 | 2.52 | ND | 0.22 | 0.22 | 0.12 | ND | 1.79 | 1.93 | 2.64 | ND |
| Severn | 0.62 | 0.64 | 1.20 | ND | 0.43 | 0.44 | 0.32 | ND | 1.05 | 1.07 | 1.53 | ND |
| West Wales | 0.02 | 0.02 | 0.07 | ND | 0.25 | 0.25 | 0.24 | ND | 0.27 | 0.28 | 0.31 | ND |
| Dee | 0.06 | 0.04 | 0.04 | ND | 0.48 | 0.48 | 0.47 | ND | 0.54 | 0.52 | 0.51 | ND |
| North West | 0.73 | 0.67 | 0.59 | ND | 0.94 | 1.24 | 0.88 | ND | 1.67 | 1.92 | 1.48 | ND |
| Solway Tweed | 0.00 | 0.00 | 0.00 | ND | 0.26 | 0.26 | 0.26 | ND | 0.26 | 0.26 | 0.26 | ND |
| Scotland | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.25 | 0.21 | 0.19 | 0.21 | 0.25 | 0.21 | 0.19 |
| North Eastern | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Neagh/Bann | 1.33* | 0.82 | 0.93 | 0.94 | 0.00 | -0.03 | -0.03 | -0.06 | 1.33 | 0.78 | 0.90 | 0.88 |

**Where:**

- ΣF The fishing mortality rate, summed over the age-groups in the stock.
- ΣH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock.
- ΣA The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.
- ND "No Data", where there are insufficient data to estimate a derived parameter (for example where there are insufficient data to estimate the stock indicators (biomass and/or mortality)).
- * The Neagh/Bann Bbest estimate for 2011 derives from an input (recruitment) period of 1992 to 1999 when recorded annual recruitment (stocking and natural) average 2068kg glass eel. Fishery management actions include enhancement by assisted migration of recruits and stocking from other RBDs.

*Table 4. The amount of glass eel stocked into UK RBDs, during 2011 to 2014.*

| RBD code | R (kg) | | | |
|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 |
| Northumbria | 0 | 0 | 0 | NR |
| Humber | 4 | 10 | 3 | NR |
| Anglian | 15.3 | 1.5 | 9.1 | NR |
| Thames | 0.01 | 1.2 | 2 | NR |
| South East | 0 | 0 | 7 | NR |
| South West | 0.5 | 0.19 | 12.8 | NR |
| Severn | 102.3 | 9.75 | 21.1 | NR |
| West Wales | 0 | 0 | 0 | NR |
| Dee | 0 | 0 | 0 | NR |
| North West | 0 | 0 | 0 | NR |
| Solway Tweed | 0 | 0 | 0 | NR |
| Scotland | NP | NP | NP | NP |
| North Eastern | 0 | 0 | 0 | 20 |
| Neagh/Bann | 1035 | 1300 | 1866 | 2690 |

**Where:**

- NR “Not Reported”, data or activity exist but numbers are not reported to authorities (for example for commercial confidentiality reasons, or not available at the time of writing).
- NP “Not Pertinent”, where the question asked does not apply to the individual case (for example where catch data are absent as there is no fishery or where a habitat type does not exist in an EMU).

# 3. Implementation of management measures

## 3.1. Describe the measures implemented since the adoption of your eel management plan, including the year of implementation and, where practical, realised or anticipated effect on silver eel escapement biomass.

The worksheets in “2. Measures implemented_EMU” for each of the EMUs in the accompanying electronic tables “UK 2015 EMP Progress Report tables.xlsx” provide a detailed list of all of the measures implemented in each RBD, categorised according to the actions on commercial fisheries, recreational fisheries, entrainment and mortality at water intakes, increasing habitat quantity and quality, stocking, and others (as per the draft ‘Guidance’).

In summary, actions implemented in England and Wales in the 2011-2013 period have delivered:

- 100% catch and release for eel by angling
- Introduced close seasons for net and trap fishing for eel
- Limits on the geographical extent of the eel fishery
- Restrictions on eel fishing methods and gear
- 328 new eel passes restoring access to over 4200ha of river habitat
- Continued progress in implementing the Eels (England & Wales) Regulations 2009 to install eel passes and screening to protect eel

In Scotland, the principal management measure of the EMP was to prohibit fishing for eels, by any method, without a licence, via legislation introduced in 2009. To date (February 2015) no licences have been issued to fish for eels in Scotland (with the exception for some small-scale scientific sampling).

In Northern Ireland, actions implemented in 2009 have continued as stated in the 2012 Review, and additional, previously not foreseen actions have been implemented as follows:

**National measures**

- Removal of fyke net as a legal fishing engine in 2010
- Raising of MLS for yellow eel from 300 to 400 mm in 2010
- Ban on the taking of eel by recreational fishing for eel in 2010, all NI RBDs
- Establishment of yellow and silver eel commercial traceability system in 2009

**Neagh/Bann RBD**

- Registration of "the Lough Neagh eel" under the EU Protected Geographical Indication status scheme thereby affording it the highest level of eel traceability within the EU in 2011
- Closure of one silver eel fishing weir in the River Bann in 2013 & 2014

**North Eastern RBD**

- Creation of glass eel monitoring site from 2012
- Glass eel stocking in 2014
- Assessment in 2013 & 2014 of wetted area impacted by barriers to eel migration (data used to populate production/escapement model).
- Installation of ascending eel pass in the River Lagan in 2014-5

With the exception of the large scale stocking in the Neagh/Bann RBD, it is not yet possible to predict whether and when these measures will achieve the required additional silver eel production across the UK. Therefore, it is not yet possible to predict when the UK will meet its targets across all RBDs. Investment in scientific research continues alongside implementation of management measures to address these uncertainties.

## 3.2. Provide an explanation for any planned measure not implemented.

There are no measures planned in the original EMPs that have not yet been implemented.

## 3.3. List any difficulties encountered in the implementation of the plan

**England and Wales**

The main difficulties encountered in implementing the measures in England and Wales were those of:

1) Identifying the owner or person responsible for some in-river obstructions. Under these circumstances it is difficult to obtain permission to resolve eel passage at that site, or to apply powers under the Eels (England and Wales) Regulations 2009; and,

2) Obtaining the necessary resources to improve access to suitable habitat or to prevent entrainment.

**Scotland**

None.

**Northern Ireland**

The stocking target for the Neagh/Bann EMP was not achieved in 2012 & 2013 because of the high price of glass eel and because glass eel were available at the wrong time of year for stocking into Lough Neagh, i.e. available in November and December when stocking into Lough Neagh is unadvised. However, with the increase in recruitment seen in the EU in 2014 and associated fall in prices the stocking target of eight million was achieved for the first time since 1988.

## 3.4. Provide any data and/or other information that would support the analysis of the potential net benefit of eel stocking in terms of silver eel escapement. Examples could include estimates of natural mortality rates for eel left in situ vs captured and stocked.

Analyses of the fate of glass eel stocked into Lough Neagh in Northern Ireland suggests that 1kg of stocked or assisted migration of glass eels yields in the range of 60-100kg of silver eels (Allen et al., 2006; Rosell *et al.*, 2005).

However, the UK considers that the pertinent information required to assess the net benefit of eel stocking to silver eel escapement revolves around *in situ* measures of mortality rates, both of eel at all stages from glass to silver if they had not been caught and used for stocking, and for eel caught and used for stocking.

The UK does not possess such a complete dataset and is not aware of such anywhere else in the natural range of the European eel. Therefore, the UK suggests that investment is required to produce such data. As eel stocking often involves several countries in the EU (and potentially outside the EU if CITES changes), the UK considers that an internationally coordinated series of studies of eel stocking should be the most efficient approach to address these requirements. The UK is happy to work with/assist the European Commission to develop this.

# 4. Proposed amendments to the Regulation

It is still too early to be confident of any changes in the stock as a result of EMP implementation, at national or international levels. Therefore, the UK does not propose any amendments to the existing Regulation at this time. However, there are a number of issues that could be help the stock recovery process and the implementation of the EU Eel Recovery Plan (the Regulation).

It is essential for a whole-stock assessment of status that national assessments are conducted under the same set of conditions, for example, that all assessments consider the same eel habitat environments.

The UK supports a strategic review at EC level considering where and when restocking might most benefit the recovery of the European eel, and initiatives to focus Community efforts on facilitating restocking under these conditions.

The traceability of eel trade within Europe has been difficult to achieve in some circumstances where practices differ between countries. This issue could be resolved if a standardised approach was introduced throughout Europe.

# 5. Glass eel prices

The evolution of the market price of glass eel is based on the price paid by the Lough Neagh Fishermen's Cooperative Society (Table 5.1).

*Table 5.1 Cost of purchasing glass eel (€ /kg).*

| Year | Cost (€) /kg |
|---|---|
| 2009 | 525 |
| 2010 | 497 |
| 2011 | 353 |
| 2012 | 475 |
| 2013 | 400 |
| 2014 | 225 |

# 6. References

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# Annex A: Methods and data used in the 2011-2013 assessment of England and Wales

## A1. Introduction

The assessment approach can be summarised as follows: the best achievable present-day silver eel escapement in the absence of human impacts ($B_{best}$) and the silver eel escapement from the historic pre-1980s reference period ($B_0$) are estimated for index rivers within each River Basin District (RBD), using an eel life history model to extrapolate yellow eel density data from surveys across a river basin to whole river estimates of yellow eel numbers at length class, converted to numbers of silver eel at length class and then to silver eel biomass using a length-weight regression, all using the Scenario-based Model of Eel Production II (SMEP II) (Aprahamian *et al.*, 2007; Walker *et al.*, 2013). Silver eel biomass for the river habitat is converted to an average silver eel production rate across the wetted area of modelled river (i.e.kg.ha$^{-1}$). This production rate is then applied to all wetted area of rivers, lakes, estuaries and lagoons (where present) across the RBD, to estimate the $B_{best}$ and $B_0$ (where historic data exist). The losses from various anthropogenic factors are estimated as silver eel equivalent biomass, and these are subtracted from $B_{best}$ to estimate the present-day silver eel escapement to the sea ($B_{current}$). The remainder of this section describes these analyses in greater detail.

## A2. $B_{best}$

Estimates of $B_{best}$ were made for three time periods as follows:

- 2005-2007
    - Used to assess emigrating biomass and mortality indicators for “Pre EMP”;
- 2008-2010*
    - Used to assess emigrating biomass and mortality indicators for 2009 and 2010;
- 2011-2013*
    - Used to assess emigrating biomass and mortality indicators for 2011, 2012 and 2013.

The assessments were based on yellow eel data stored on the National Fish Population Database (NFPD). Only quantitative density and biomass data were included and therefore the following survey types and data were excluded:

- Fishing methods:
    - Fyke netting

  - Fixed traps fishing
  - Portable traps fishing
  - Trapping
  - Dip netting
  - Gill netting
  - Kick sampling
  - Trawl netting
  - Timed surveys
- Where the fished area was less than 10 $m^2$.
- Where the biomass recorded was greater than 3000g/100 $m^2$.
- Where the length of eel recorded was <50 mm.

$B_{best}$ was estimated for 44 rivers across the eleven RBDs (Table A1). With the exception of the Humber and Dee RBDs, multiple rivers were analysed for each RBD. In such cases, the RBD-level estimate of $B_{best}$ was the mean output for the various rivers sampled in that RBD (Table A2).

*Table A1. Best potential silver eel production ($B_{best}$) (kg.ha$^{-1}$) for the rivers analysed for the periods 2005-07, 2008-2010 and 2011-2013.*

| RBD | River | $B_{best}$ (kg.ha$^{-1}$) 2005-2007 | $B_{best}$ (kg.ha$^{-1}$) 2008-2010 | $B_{best}$ (kg.ha$^{-1}$) 2011-2013 |
|---|---|---|---|---|
| Northumbria | Coquet | 0.00 | 0.35 | 0.38 |
| | Wear | 1.41 | 6.96 | 0.77 |
| Humber | Humber | 0.57 | 0.79 | 1.14 |
| Anglian | Great Ouse | 1.91 | 0.43 | 0.63 |
| | Suffolk Stour | 2.85 | 2.58 | 1.27 |
| | Wensum | 1.70 | 1.29 | 1.30 |
| | Witham | 4.27 | 4.41 | 2.88 |
| | Welland | 5.37 | 4.36 | 5.28 |
| | Chelmer & Blackwater | 11.4 | 4.26 | 3.48 |
| | Nene | 3.90 | 1.27 | 0.97 |
| Thames | Lee | 3.60 | 1.18 | 1.94 |
| | Medway | 0.99 | 1.80 | 1.21 |
| | Thames | 1.95 | 2.05 | 1.40 |
| South East | Ouse | 2.41 | 1.03 | 2.24 |
| | Itchen | 6.17 | 12.63 | 7.83 |
| | Test | 3.60 | 12.35 | 6.14 |
| South West | Dorset Stour | 0.14 | 5.02 | 0.53 |
| | Exe | 0.04 | 0.78 | 0.04 |
| | Fowey | 0.67 | 1.47 | 0.24 |
| | Frome | 4.54 | 8.46 | 3.18 |
| | Hampshire Avon | 1.70 | 3.00 | 2.76 |
| | Otter | 0.16 | 0.76 | 0.63 |
| | Parrett | 0.04 | 0.21 | 1.08 |
| | Plym | 3.34 | 1.81 | 2.95 |
| | Tamar | 0.11 | 0.35 | 0.06 |
| | Taw | 0.00 | 0.03 | 0.01 |

| | | | | |
|---|---|---|---|---|
| | Teign | 0.01 | 0.05 | 0.11 |
| Severn | Severn | 1.18 | 1.48 | 1.33 |
| | Wye | 0.07 | 0.28 | 0.58 |
| | Usk | 0.09 | 4.42 | 1.49 |
| Western Wales | Clwyd | No estimate | 0.05 | 0.07 |
| | Teifi | No estimate | 0.89 | 2.44 |
| | Tywi | No estimate | 0.97 | 0.03 |
| | Wnion | No estimate | 1.15 | 2.04 |
| Dee | Dee | 0.35 | 2.15 | 2.44 |
| North West | Bela | No estimate | 4.80 | 0.54 |
| | Derwent | 0.05 | 0.31 | 0.29 |
| | Ellen | 3.40 | 0.01 | 0.06 |
| | Mersey | 0.00 | 0.11 | 0.16 |
| | Ribble | 0.44 | 1.33 | 0.72 |
| | Weaver | 1.12 | 0.03 | 0.00 |
| Solway Tweed | Border Esk | 0.13 | 1.65 | 0.37 |
| | Eden | 0.10 | 0.20 | 0.09 |
| | Tweed | No estimate | 1.28 | 0.57 |

*Table A2. $B_{best}$ (kg.ha$^{-1}$) for the periods 2005-2007, 2008-2010 and 2011-2013 for each River Basin District. Note the estimates for the Humber and Dee are single estimates whereas those for the other RBDs are the averages of 2 to 11 rivers.*

| RBD | $B_{best}$ (kg.ha$^{-1}$) 2005-2007 | $B_{best}$ (kg.ha$^{-1}$) 2008-2010 | $B_{best}$ (kg.ha$^{-1}$) 2011 - 2013 |
|---|---|---|---|
| Northumbria | 0.71 | 3.66 | 0.58 |
| Humber | 0.57 | 0.79 | 1.14 |
| Anglian | 4.49 | 2.66 | 2.26 |
| Thames | 2.18 | 1.68 | 1.52 |
| South East | 4.06 | 8.67 | 5.40 |
| South West | 0.98 | 1.99 | 1.05 |
| Severn | 0.45 | 2.06 | 1.13 |
| West Wales | No estimate | 0.77 | 1.15 |
| Dee | 0.35 | 2.15 | 2.44 |
| North West | 1.00 | 1.10 | 0.30 |
| Solway Tweed | 0.12 | 1.04 | 0.34 |

# A3. Anthropogenic mortality factors and $B_{current}$

The impacts of the anthropogenic (human-induced) mortality factors have been summarised according to four categories as follows:

1. Fishing mortality, relates to the catch of all life stages;
2. Entrainment and mortality at water intakes, includes mortality from pumping stations, critical surface water abstractions, power stations and hydropower facilities;
3. Habitat quantity and quality, relates to the impact of manmade obstructions (including tidal gates); and
4. Stocking, reflects the benefit of stocking and has been reported as a negative impact.

## A3.1. Fishing mortality

*Recreational catch*

It has been illegal to kill eel caught by recreational fishing in England and Wales since 2009. Anyone who does catch an eel on rod-and-line (the only legal recreational instrument) must return it alive to the water from where it was taken. Therefore it is assumed that there is no recreational catch of eel.

*Commercial catch*

Catch data were available from the glass eel and from the yellow and silver eel fisheries. In 2009, legislation was introduced to improve the traceability of eel caught, such that there are now three sources of glass eel exploitation data:

1. Catch returns to the Agency - this provides a breakdown of catch by RBD but may underestimate the total catch ($C_i$)
2. The quantity of glass eel bought by the dealers from the fishermen (consignment notes) - this is the total amount of glass eel caught ($C_t$)
3. The quantity of glass eel exported from the UK or stocked within the UK - this is the total amount of glass eel caught minus mortality and weight loss post-capture.

For the period 2009 to 2013, the glass eel catch in RBDi was calculated as follows, using the nomenclature 1, 2 and 3 above:

$$G_i = C_t \cdot \left(\frac{C_i}{\sum_{c=0}^{n} C_i}\right)$$

For the years 2006 – 2008 the estimate of the total glass eel caught in each RBD was:

$$G_i = C_i \cdot \frac{\overline{C}_{t\,(2009-2011)}}{\sum_{c=0}^{n} \overline{C}_{i(2009-2011)}}$$

For 2005 and the early 1980s (Pre 1980 in Table 3) the estimates for both glass and yellow & silver eel (combined) were derived from the import export figures published in the country report (http://ices.dk/community/Documents/Expert%20Groups/WGEEL/WGEEL_CountryReports_2014.pdf); Table 2 page 830 & Table 26 Page 855, respectively. The partition of the catch to individual RBDs was based on the current split in the total catch based on the mean proportions between 2005 and 2013.

The catch for the Solway Tweed RBD prior to the ban on eel fishing in Scotland was assumed to be 10% of the total Scottish catch as the Scottish part of the Solway Tweed represents ~10% of the fresh water habitat of Scotland.

Yellow and glass eel catches were converted to silver eel equivalents, as follows:

The biomass of yellow eel caught was considered to be the equivalent of the potential silver eel escapement as the instantaneous mortality rate of 0.14 $yr^{-1}$ (Dekker, 2000)

approximated to the instantaneous growth rate of 0.2 $yr^{-1}$ (95% CI ± 0.03) (Aprahamian, 1986).

For the glass eel catch, 1kg of glass eel was considered equivalent to 59.4kg of silver eel. This was determined assuming:

1. a settlement instantaneous mortality of 0.00915 day-1, (95% CI ± 0.00149 day-1) based on an extrapolation from the study of Bisgaard and Pederson (1991) to a glass eel of 80mm;
2. a settlement period of 50 days (Briand, 2009) assuming a water temperature of 9oC;
3. an annual instantaneous mortality following settlement of 0.14 yr-1 (Dekker, 2000);
4. a 50:50 sex ratio; and
5. males maturing at 11.9 (95% CI ± 0.6) (@ 89.9g (95% CI ± 3.7g)) and females at 17.8 (95% CI ± 0.8) years (@ 568.9g (95% CI ± 57.1g)) (Aprahamian, 1988).

Thus, the losses due to commercial fishing were estimated with the following formula:

$$Banthro_{fi} = \sum_{g=0}^{n} G_i .59.4 + \sum_{y=0}^{n} Y_i + \sum_{s=0}^{n} S_i$$

Where:

- $Banthro_{fi}$ is the biomass (kg) of eel in terms of silver eel equivalents that is estimated that would be produced in $RBD_i$ if no fishing was present.
- $G_i$ is the biomass (kg) of glass eel caught in fishery g in $RBD_i$ (Table A3).
- $Y_i$ is the biomass (kg) of yellow eel caught in fishery y in $RBD_i$ (Table A4).
- $S_i$is the biomass (kg) of silver eel caught in fishery s in $RBD_i$ (Table A5).

*Table A3. Glass eel catch (kg) by River Basin District (RBD)*

| RBD | Pre 1980 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Northumbria | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Humber | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Anglian | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thames | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South East | 8 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South West | 17919 | 3225 | 722 | 999 | 521 | 282 | 1079 | 2033 | 2161 | 4536 |
| Severn | 24454 | 4055 | 944 | 1750 | 554 | 111 | 759 | 1460 | 1586 | 3948 |
| West Wales | 1998 | 457 | 55 | 39 | 6 | 0 | 2 | 4 | 0 | 34 |
| Dee | 795 | 202 | 8 | 9 | 3 | 1 | 7 | 21 | 23 | 22 |
| North West | 4827 | 860 | 174 | 299 | 137 | 28 | 43 | 123 | 49 | 119 |
| Solway Tweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table A4. Yellow eel catch (kg) by River Basin District (RBD)*

| RBD | Pre 1980 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Northumbria | 93 | 5 | 1 | 0 | 0 | 45 | 60 | 0 | 0 | 0 |
| Humber | 17970 | 1295 | 1160 | 2138 | 1429 | 411 | 3033 | 4857 | 3267 | 3865 |
| Anglian | 76619 | 13065 | 6282 | 3739 | 9903 | 6616 | 10708 | 16478 | 15335 | 9351 |
| Thames | 39920 | 7175 | 5688 | 6963 | 5548 | 4745 | 5655 | 6082 | 1815 | 3991 |
| South East | 15600 | 406 | 3069 | 1807 | 602 | 7029 | 1432 | 1879 | 2116 | 286 |
| South West | 35960 | 3787 | 6788 | 2019 | 6626 | 2546 | 2722 | 3792 | 5966 | 8688 |
| Severn | 1113 | 565 | 170 | 68 | 27 | 0 | 150 | 350 | 0 | 0 |
| West Wales | 2070 | 240 | 475 | 273 | 118 | 22 | 345 | 252 | 647 | 100 |
| Dee | 2146 | 34 | 28 | 23 | 642 | 70 | 53 | 1082 | 478 | 152 |
| North West | 7484 | 1619 | 1250 | 211 | 474 | 114 | 150 | 1477 | 2972 | 669 |
| Solway Tweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table A5. Silver eel catch (kg) by River Basin District (RBD)*

| RBD | Pre 1980 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Northumbria | 82 | 0 | 0 | 0 | 90 | 10 | 0 | 0 | 0 | 0 |
| Humber | 5007 | 243 | 323 | 2188 | 865 | 110 | 199 | 257 | 1627 | 259 |
| Anglian | 16538 | 6659 | 2417 | 198 | 1974 | 592 | 739 | 2006 | 2980 | 2486 |
| Thames | 3408 | 1067 | 971 | 484 | 404 | 119 | 67 | 513 | 200 | 308 |
| South East | 15939 | 3594 | 4104 | 2621 | 1650 | 3198 | 823 | 694 | 650 | 1991 |
| South West | 5433 | 1886 | 1896 | 228 | 552 | 303 | 172 | 68 | 533 | 950 |
| Severn | 2052 | 396 | 146 | 124 | 117 | 1224 | 100 | 380 | 0 | 0 |
| West Wales | 207 | 10 | 31 | 140 | 10 | 43 | 9 | 9 | 0 | 0 |
| Dee | 180 | 10 | 6 | 9 | 15 | 14 | 15 | 119 | 0 | 31 |
| North West | 2178 | 202 | 1103 | 85 | 263 | 80 | 72 | 270 | 462 | 105 |
| Solway Tweed | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# A3.2. Entrainment

### Pumping stations

In England and Wales, 336 of the 946 pumping stations were identified as having the greatest potential to impact on eel, based on: 1) distance from head of tide; and 2) the predicted prevalence of eel. The predicted prevalence was estimated using a non-parametric geostatistical model (Wyatt, 2005 and Wyatt, *et al*., 2007) that related the prevalence of eel to environmental variables (distance from the tidal limit and altitude), and geographic location. The model was used to predict the expected prevalence of eel for a given river type under reference conditions, the pressure variables being set to zero (WFD-UKTAG, 2008a).

To estimate the impact it has been assumed that all the area upstream of the pumping station was lost to eel production (Table A6). The total annual loss in terms of silver eel biomass for RBD (i) was estimated as follows:

$$Banthro_{ji} = \sum_{j=0}^{n} (Bbest_i . A_{ji})$$

Where:

- $Banthro_{ji}$ is the biomass (kg) of silver eel that is estimated would be produced in catchment j in $RBD_i$ if no pumping station was present.
- $Bbest_i$ is the estimate biomass ($kg.ha^{-1}$) of silver eel potentially escaping $RBD_i$ in the absence of any anthropogenic factors.
- $A_{ji}$ is the wetted area (ha) upstream of the pumping station in catchment j in $RBD_i$.

*Table A6. Area of habitat lost to eel production (ha) from those pumping stations with the greatest potential to impact eel*

| RBD | Area of habitat lost to eel production (ha) |
|---|---|
| Northumbria | 5 |
| Humber | 3897 |
| Anglian | 5234 |
| Thames | 28 |
| South East | 797 |
| South West | 1621 |
| Severn | 119 |
| West Wales | 0 |
| Dee | 0 |

| | |
|---|---|
| North West | 366 |
| Solway Tweed | 0 |

**Surface water abstractions**

Surface water is abstracted at 23,087 sites in England and Wales. A total of 539 sites were identified as posing the greatest threat to eel (Table A7) using the following criteria: distance from head of tide, size of the abstraction, predicted presence of eel, the sensitivity of the water body to abstraction (WFD-UKTAG, 2008b). These identifications were also quality assured by consultation with local experts.

Information on eel entrainment and mortality was available from 10 surface water abstraction sites (APEM, 2007; APEM, 2010; Frear and Axford, 1991). The annual number of eel entrained at these 10 sites ranged from zero to 3261 with a mean 613.8 (95% CI ± 613.8) eel per year. The average age of those eel was assumed to be two years, which equates to about 150mm total length. The equivalent in terms of silver eel biomass (calculated as above) was estimated to be 0.03kg per entrained eel, equating to 19.2 (95% CI ± 19.2)kg.yr$^{-1}$ entrained per abstraction.

The total annual loss in terms of silver eel biomass for $RBD_i$ (Table A7) was therefore estimated as follows:

$$Banthro_{ki} = \sum_{k=0}^{n} K_i . 19.2$$

- $Banthro_{ki}$ is the biomass (kg) of silver eel that is estimated that would be produced in $RBD_i$ if no surface water abstraction was present.
- K is the number of surface water abstractions in $RBD_i$.

*Table A7. Number of critical abstractions and estimated loss of emigrant biomass.*

| RBD | Number of Critical (High priority) surface water abstractions | Estimated biomass of silver eel entrained (kg.yr-1) |
|---|---|---|
| Northumbria | 11 | 211 |
| Humber | 19 | 365 |
| Anglian | 128 | 2458 |
| Thames | 33 | 634 |
| South East | 45 | 864 |
| South West | 73 | 1402 |
| Severn | 14 | 269 |
| West Wales | 83 | 1594 |

| | | |
|---|---|---|
| Dee | 12 | 230 |
| North West | 115 | 2208 |
| Solway Tweed | 6 | 115 |

**Cooling water intakes at Power Stations**

There are 58 power stations across England and Wales where eels may be impacted by cooling water intakes. Information on eel impingement and/or entrainment at cooling water intakes of power stations was available from five sites.

At three sites only impingement data were available and to account for the quantity of eel that passed through the screens, the catch was raised by x300 for glass eel and x4.3 for yellow eel (APEM, 2012). There was no correction factor applied for silver eel.

For those two sites where no size information was available, it was assumed that those eel caught between February 1st and April 30th were glass eel, with yellow eel being caught at all other times. A survival rate of 36% was assumed for glass eel and 75% for yellow eel entrained by the power station (APEM, 2012; Jacobs, 2008). The conversion of glass eel and yellow eel entrainments into silver eel equivalents was as described for the commercial catch (above). The estimated annual biomass of silver eel equivalents entrained by a power station was 697.6kg.yr$^{-1}$ (95% CI ± 724.2kg.yr$^{-1}$).

The total annual loss in terms of silver eel biomass for $RBD_i$ (Table A8) was estimated as follows:

$$Banthro_{li} = \sum_{i=0}^{n} L_i \,.\, 697.6$$

$Banthro_{li}$ is the biomass (kg) of silver eel that is estimated that would be produced in $RBD_i$ if no power station was present.

L is the number of power stations in $RBD_i$.

*Table A8. Number of power stations and estimated loss of emigrant biomass.*

| RBD | Number of Power Stations | Estimated biomass of silver eel entrained (kg.yr-1) |
|---|---|---|
| Northumbria | 3 | 2093 |
| Humber | 19 | 13255 |
| Anglian | 3 | 2093 |
| Thames | 12 | 8372 |
| South East | 5 | 3488 |
| South West | 2 | 1395 |
| Severn | 2 | 1395 |

| | | |
|---|---|---|
| West Wales | 2 | 1395 |
| Dee | 3 | 2093 |
| North West | 7 | 4884 |
| Solway Tweed | 0 | 0 |

**In-river Hydropower facilities (turbines)**

The impact of each in-river hydropower facility was estimated according to the $B_{best}$ production (kg.ha$^{-1}$) for the relevant RBD, the area of habitat upstream, the presence or absence of screens (preventing eel entrainment) and the type of turbine.

For those sites with screens (α), the proportion of eel entering the turbine(s) was assumed to be zero if the spacing between the bars / mesh was <15 mm, 50% if the spacing was between 16 – 29 mm and 100% if > 30mm: 27.6% of hydropower schemes (excluding Archimedes screws) are adequately screened to prevent the entrainment of eel (i.e. spacing was < 15 mm).

The estimates of turbine mortality (β) were taken from ICES (2011) and were: Archimedes screw 0%; Francis Turbine 32%; Kaplan turbine 38%. All hydropower facilities have some form of bypass channel that provides an alternative route for fish around the turbine. On this basis, it has been assumed that approximately 50% of the silver eels produced upstream of a turbine will become entrained therein while the other 50% use the bypass.

On those river systems where there is more than one hydropower facility, the loss of production from the upstream turbine(s) has been accounted for in estimating the potential impact of turbines further downstream, i.e. the cumulative impact of all turbines has been calculated (Table A9).

$$Banthro_{hi} = \sum_{h=0}^{n} ((Bbest_i . A_{hi}) - ((Bbest_i . A_{h_u i})\alpha_{h_u}\beta_{h_u}))\alpha_h\beta_h$$

Where:

- $Banthro_{hi}$ is the biomass (kg) of silver eel that is estimated that would be produced in RBD$_i$ if no hydropower facilities (h) were present.
- $h_u$ represents the hydro scheme upstream of hydropower station $h$.

*Table A9. Estimated loss of emigrant biomass (kg.yr$^{-1}$).*

| RBD | Estimated loss of emigrant biomass (kg.yr$^{-1}$) 2005-2007 | Estimated loss of emigrant biomass (kg.yr$^{-1}$) 2008-2010 | Estimated loss of emigrant biomass (kg.yr$^{-1}$) 2011-2013 |
|---|---|---|---|
| Northumbria | 10 | 53 | 8 |
| Humber | 575 | 592 | 619 |
| Anglian | 0 | 0 | 0 |
| Thames | 3 | 2 | 2 |
| South East | 63 | 135 | 84 |
| South West | 862 | 867 | 863 |
| Severn | 8 | 27 | 17 |
| West Wales | 33 | 37 | 56 |
| Dee | 2 | 10 | 12 |
| North West | 79 | 84 | 47 |
| Solway Tweed | 0 | 1 | 0 |

## B3.3. Habitat loss

### Barriers

There are about 19,000 potential barriers (partial and complete barriers) to eel migration across England and Wales. The impact of barriers (including tidal gates) was estimated using a general linear model derived from eel data in 27 rivers from 2008 to 2013 ($r^2$ = 0.196):

$$\gamma_b = e^{(-2.6545-(0.302Log_e(\delta+1))-(0.0401Log_e(\varepsilon+1))-(55.3Log_e(\zeta+1))-(0.2906Log_e(\eta+6))+(1.7152Log_e\theta))-1}$$

Where:

- $\gamma_b$ is density (# 100m$^{-2}$) of eel in the presence of barriers downstream
- δ is distance (m) upstream of tidal limit
- ε is the number of barriers downstream of the site to the tidal limit
- ζ is the gradient (m m$^{-1}$) to the site
- η is the longitude ($^{o}$East) of the site

- θ is latitude ($^{o}$North) of the site.

The anthropogenic effect of barriers was estimated by setting ε in the above equation to zero and comparing the ratio of density as estimated from the above equation in the presence and absence of barriers. The average of all these site ratios was applied to the RBD as a whole, as follows:

$$Banthro_{bi} = \frac{Bcurrent_i}{\overline{\gamma_{bi}/\gamma_i}} - Bcurrent_i$$

$Banthro_{bi}$ is the biomass (kg) of eel in terms of silver eel equivalents that is estimated that would be produced in $RBD_i$ if no barriers were present.

$\overline{\gamma_{bi}/\gamma_i}$ is the mean proportion of eel density in the presence of barriers against no barriers present (ε = 0) at sites within $RBD_i$.

## B3.4. Stocking

Stocking was undertaken using glass eel (Table A10) and converted into silver eel equivalents as described for commercial catch (above). The impact of stocking was considered to be a negative anthropogenic factor in the estimation of total non-fisheries mortality (∑H) and total anthropogenic mortality (∑A) (i.e. stocking has a positive impact on silver eel escapement). No stocking-related mortality was assumed in these calculations.

*Table A10. Amount of glass eel stocked (kg), by RBD from 2009 – 2013. Note that these glass eel all originated in the RBDs of England and Wales.*

| RBD | 2009 (kg) | 2010 (kg) | 2011 (kg) | 2012 (kg) | 2013 (kg) |
|---|---|---|---|---|---|
| Northumbria | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Humber | 18.50 | 38.00 | 0.00 | 10.00 | 3.00 |
| Anglian | 4.60 | 15.20 | 11.30 | 1.50 | 9.10 |
| Thames | 0.00 | 0.00 | 0.01 | 1.20 | 2.00 |
| South East | 0.00 | 0.00 | 0.00 | 0.00 | 7.00 |
| South West | 0.00 | 0.00 | 0.00 | 0.19 | 12.80 |
| Severn | 0.00 | 0.40 | 38.83 | 9.75 | 21.10 |
| West Wales | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dee | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| North West | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Solway Tweed | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## B4. Estimation of $B_o$

There are few historic eel surveys available across England and Wales that provide the density, length frequency and sex ratio data necessary to apply the SMEP II approach to estimate RBD-specific $B_0$. The rivers and survey years available are presented in Table A11.

Complete data are only available from the Severn (1983), Dee (1984) and Thames (1992-1994). These data were applied directly in the SMEP II model to estimate historic potential production (~$B_{best}$), applying the same approach as described for estimating current $B_{best}$, above.

As no length data were recorded for the Anglian rivers Stour and Chelmer, the mean eel length for a site was estimated from other rivers as follows:

*Mean length (mm) = 281.0 (±15.54) + 0.9879 (±0.245) * Distance from tidal limit (km)*
*$P<0.001$; $r^2 = 0.23$*

The length distribution was estimated using a random number generator based on the mean length (calculated above), a standard deviation (SD) of 102 (the mean SD of all sites where length had been recorded), and assuming a binomial distribution.

As only the mean length and SD were available for the South West rivers (Frome, Fowey Teign, Axe, Otter and Plym), the length distribution was estimated using a random number generator, assuming a binomial distribution.

*Table A11. Estimates of silver eel potential escapement (kg.ha$^{-1}$) for various rivers between 1979 and 1994.*

| RBD | River (Year) | Potential escapement (kg.ha$^{-1}$) |
|---|---|---|
| Anglian | Suffolk Stour (1983) | 0.73 |
| | Chelmer (1986) | 0.88 |
| Thames | Thames (1992-1994) | 2.35 |
| South West | Frome 1990 | 82.54 |
| | Fowey 1981 &1983 | 3.06 |
| | Teign 1979 | 2.20 |
| | Axe 1979 | 56.78 |
| | Otter 1978 | 27.24 |
| | Plym 1982 | 7.17 |
| Severn | Severn (1983) | 6.84 |
| Dee | Dee (1984) | 29.89 |

Where potential escapement estimates were available for two or more rivers in the same RBD, the river-specific estimates were combined to provide an average estimate for the RBD. For the South West RBD, the mean escapement was estimated based on the assumption that 14% of the production is derived from chalk streams (River Frome) and 86% from rain fed rivers (rivers Fowey Teign, Axe, Otter, Plym) as follows:

*SW RBD (kg.ha$^{-1}$) = ((Frome*0.138876) + ((Fowey +Teign + Axe + Otter + Plym)/5) * (1-0.138876))*

In the Anglian RBD, the two rivers were given equal weighting because the rivers are similar in character.

Where no historic data were available for any rivers within the RBD, the following assumptions have been made:

- The east coast RBDs (Northumbria, Humber and South East) follow a similar trajectory to that of the Anglian, where current escapement ($B_{best}$) is greater than "historic" and therefore current production has been taken as $B_o$.

- The West Wales and North West RBDs were extrapolated from the South West (excluding chalk rivers), Severn and Dee estimates, weighted according to wetted areas.

- The Solway-Tweed estimate was extrapolated from the estimates of the North West and Northumbria RBDs, weighted according to wetted areas.

These potential escapement estimates were then corrected for the impact of barriers (as above) to give an estimate of $B_o$ for each RBD (Table A12).

*Table A12. Estimates of $B_o$ (kg.ha$^{-1}$) for River Basin Districts in England and Wales and for the cross border Solway Tweed RBD.*

| River Basin District | $B_o$ In the presence of barriers (kg.ha$^{-1}$) | $B_o$ In the absence of barriers (kg.ha$^{-1}$) | Comment |
|---|---|---|---|
| Northumbria | 3.66 | 5.16 | Based on current estimate and the rationale from Anglian that current is higher than historic and as 2008-2010 (3.25kg.ha$^{-1}$) > 2011-2013 (0.63kg.ha$^{-1}$) |
| Humber | 1.14 | 2.38 | Based on current estimate and the rationale from Anglian that current is higher than historic and as 2011-2013 (1.14kg.ha$^{-1}$) > 2008-2010 (0.79kg.ha$^{-1}$) |
| Anglian | 4.49 | 6.27 | Based on current estimate (2005-2007) being higher than historic (0.81kg.ha$^{-1}$). |
| Thames | 2.35 | 5.88 | Thames (1992-1994) |
| South East | 8.67 | 10.60 | Based on current estimate and the rationale from Anglian that current is higher than historic and as 2008-2010 (8.67kg.ha$^{-1}$) > 2011-2013 (5.40kg.ha$^{-1}$) |
| South West | 28.07 | 37.03 | Pristine production based on 1979-1990 data (28.07kg.ha$^{-1}$) determined using SMEP II (assumes:14% production from chalk rivers of 82.5kg.ha-1, the remainder from rain fed rivers at 19.3kg.ha$^{-1}$ |
| Severn | 6.84 | 11.98 | Severn 1983 |
| West Wales | 13.98 | 16.18 | Pristine production estimated at 13.98kg.ha$^{-1}$ based on South West (excluding chalk rivers), Severn and Dee weighted according to area = ((19.29*31050) + (6.84*54542) + ( 29.89*14129)) / 99721 |
| Dee | 29.89 | 45.02 | Dee 1984 |

| | | | |
|---|---|---|---|
| North West | 13.98 | 18.50 | Pristine production estimated at 13.98kg.ha$^{-1}$ based on South West (excluding chalk rivers), Severn and Dee weighted according to area = ((19.29*31050) + (6.84*54542) + (29.89*14129)) / 99721 |
| Solway Tweed | 13.01 | 16.84 | Based on South West (excluding chalk rivers), Severn and Dee weighted according to area and Tweed production for 2008-2010 based on the rational that current production on the east coast is higher than historic. Assumed 13.98kg.ha$^{-1}$ for Solway and 1.28kg.ha$^{-1}$ for Tweed (2008-2010) |

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# Annex B: Methods and data used in the 2012-2014 assessment of Scotland RBD

## B1. Introduction

There are no fisheries for eel in Scotland, having been banned without licence since 2009, as the principle management measure of the Eel Management Plan (EMP) for Scotland River Basin District (RBD). Previous fisheries were not regulated, and only crude estimates of the scale of the fishery are available (Anon, 2010). Stock assessment methods for the RBD are therefore based on scientific estimates of upstream and downstream counts of eel at traps on three rivers. The estimates of $B_0$, $B_{current}$ and $B_{best}$ rely on the extrapolation of data from small study areas to the RBD as a whole, with the inherent possibility of bias. To derive an estimate of current production and anthropogenic mortality for the RBD from the available data has required a number of assumptions; these have tended to be precautionary in nature (i.e. likely to underestimate current production and overestimate current anthropogenic mortality (see Anon 2010 for details).

From 2013, and following the methods used in England and Wales, Scotland has adopted the inclusion of a silver eel production estimate for transitional waters based on the simplistic assumption that this is equivalent to silver eel production in the lower lying rivers and lochs of Scotland. Pristine production for transitional waters is assumed to be equivalent to pristine production in Scottish freshwaters during the reference period. For this reason, the inclusion of transitional waters has a relatively small effect on modelled silver eel output as a percentage of pristine output. However, because anthropogenic mortality is assumed to be zero in transitional waters, as there are no fisheries, the inclusion of transitional waters leads to a substantial reduction in the estimate of the value of $\sum A$ for the Scotland RBD. All figures in the current report have been back-calculated to include production from transitional waters, and thus do not match equivalent figures in the 2012 report to the EU.

## B2. $B_{best}$

Current production in Scottish waters is assumed to be limited only by recruitment and barriers to productive habitat. Accordingly $B_{best}$ is estimated in the same way as $B_{current}$, but including potential production from the habitat area currently assumed to be lost to production due to manmade barriers (including hydropower). This amounts to 42,670 ha of potential eel habitat, of which 31,545 ha are in the lower altitude band, 8,725 ha in the middle band, and 2,400 ha are in the upper band. It is worth noting that the reported area of habitat above manmade barriers is artificially increased, by an unknown extent, above the natural condition, due to the impoundment of waters above dams; accordingly $B_{best}$ is

over-estimated by this method, which in turn leads to an overestimate of mortality due to manmade barriers and hydropower facilities.

## B3. Anthropogenic mortality factors and $B_{current}$

The impact of manmade barriers on eel production was estimated in the most conservative way possible: by assuming that all barriers were total and acted to remove all production upstream of the barrier without increasing production downstream (i.e. an assumption that downstream habitat is completely saturated). Hydropower facilities were treated in the same way, even where fish passes allow eels access above the turbines: in this case the conservative assumption is that silver eel mortality moving downstream through the turbines is 100%. Thus three assumptions are made which overestimate the impact of barriers on eel production: 1) All identified barriers completely exclude eels; 2) all hydropower sites cause 100% mortality of silver eels passing through them; 3) the wetted area of Scotland RBD is 100% saturated with eels. Thus, any wetted areas above hydropower facilities, or other manmade barriers, were removed from the productive area when estimating current production, and the production lost as a consequence was regarded as anthropogenic mortality ($\sum A$), with the separate impacts of a) hydropower facilities and b) other manmade barriers to eels estimated according the area of production lost to each (5,574ha lost to hydropower, and37,096 ha lost to other manmade barriers).

Current silver eel output ($B_{current}$) is estimated at three whole river trap sites, with no known anthropogenic mortality, which measure production across three altitude bands: Shieldaig (0-240 m), Girnock (240-415 m), Baddoch (>415 m). The annual production from these three bands is then calculated from the production at the relevant site and the wetted area of habitat in that altitude band in the RBD as a whole. The total wetted area of freshwater for Scotland RBD, after excluding habitat above manmade barriers, is 111,069ha, of which 97,684ha lie in the 0-240 m band, 10,853ha in the 240-415 m band, and 2,532ha in the >415 m band. Production in transitional waters (60,502ha) is assumed to be equivalent to the lowest of the three altitudinal bands.

Estimates of silver eel production for pristine conditions (pre-1980), for current production in the period immediately prior to the introduction of the EMP (mean 2006-2008), and for each of the subsequent years are shown in Table B1.

*Table B1. Estimates of silver eel escapement in Scotland RBD in three altitude bands based on whole-river traps at three sites (kg.ha$^{-1}$)*

| Altitude band (m) | Pre-1980 | Pre-EMP (2006-8) | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| 0-240 | 1.18 | 1.15 | 1.25 | 0.66 | 0.57 | 0.54 | 0.77 | 2.34 |
| 240-415 | 1.18 | 0.59 | 0.55 | 0.18* | 0.38 | 1.05 | 0.56 | 0.29 |
| >415 | 1.18 | 0.53 | 0.66 | 0.13 | 0.59 | 0.48 | 0.43 | 0.83 |

*Minimum figure, trapping was interrupted for two weeks during the emigration season.

For the period prior to the introduction of the EMP (and the cessation of the fishery), additional mortality estimates due to the fishery were based on available estimates of the size of the fishery in 2003, yellow eel catches were scaled to silver eel equivalents after Aprahamian (1986).

## B4. Estimation of $B_0$

The pristine production of Scottish waters was estimated in three ways: based on historical silver eel production at a single Scottish site (Girnock Burn) in the period from 1967-1981; by reference to the historical production at a similar site (Burrishoole, Ireland, 1971-79, (ICES 2008)); and by reference to an Irish model (ICES 2008) of five catchments accounting for catchment geology. All three methods gave similar estimates of silver eel production inkg.ha$^{-1}$, and the mean of the three estimates was set as Scotland RBD's pristine production. This estimate of production was then applied to the wetted area of habitat in Scotland, estimated by GIS methods. Areas above natural barriers to eel migration were excluded from the pristine productive wetted area, but areas above manmade barriers (of any era of construction) were included in the pristine productive area. These methods are described in detail in the Scotland RBD EMP (Anon 2010). Since production of the EMP however, the estimate of pristine production using Girnock Burn data was adjusted to account for a proportion of eels bypassing the trap in spate conditions, as it also was for the 2012 report to the EU. This led to a slight increase in estimated pristine production (averaged from the three methods) to 1.18kg.ha$^{-1}$.

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# Annex C: Best estimates of silver eel escapement for Northern Ireland RBDs

### Neagh/Bann RBD

In Northern Ireland, the monitoring of silver eel migration and subsequent estimations of silver eel escapement from the Neagh/Bann RBD are carried out by direct measurement. Given the geography of the RBD, in particular the single outflow point of Lough Neagh via the Lower River Bann at Toome, it was possible to initiate an annual mark-recapture programme in 2003, with the objective of estimating escapement of silver eels from Lough Neagh based on the non-recaptured proportion of those tagged silver eels taken back upstream and released. This work was further enhanced and corroborated by implementing a hydro-acoustic tracking study (a not foreseen, but implemented measure) in 2011. To date, 6779 eels have been tagged with Floy™ Tags since 2003 and recaptures recorded at both silver eel sites in the RBD. Specific details of this mark recapture escapement assessment are outlined in Section 11.1 of the Neagh/Bann EMP.

### North Eastern RBD

The estimate of pristine escapement from the North Eastern RBD was calculated with reference to the ecology and hydrology of similar systems (option c Article 5 of the Regulation) as described in Section 2.4.1 of the North Eastern EMP. Current escapement is unknown and not monitored as there are no fisheries in this RBD, but all rivers and upland lakes which are suitable for eel have been assessed as having no or minimal barriers to migration. As such under adequate recruitment levels and an adherence to the management actions laid down in the North Eastern EMP, this RBD should reach or better the 40% target naturally. Data relating to eel population densities and age distribution gathered for assessment purposes are to be included in an eel production and escapement modelling exercise as agreed and devised by the All-Ireland Standing Scientific Committee on Eel (SSCE). This work scheduled from March 2015 onwards and therefore does not form part of the current report.