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Eel Management plans for the United Kingdom

Scotland River Basin District

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Department for Environment Food and Rural Affairs

Contents

Introduction

The European eel, *Anguilla anguilla,* is widely distributed throughout European estuarine and inland waters. Estimates at the glass eel stage indicate that recruitment across Europe has fallen to below five percent of historic levels. ICES advises that the stock is outside safe biological limits and that current fisheries are not sustainable (ICES, 2008).

The European Commission has initiated an Eel Recovery Plan (Council Regulation No 1100/2007) to try to return the European eel stock to more sustainable levels of adult abundance and glass eel recruitment. Each Member State is required to establish national Eel Management Plans (EMPs). These plans aim to achieve an escapement of silver eel to the spawning population that equals or exceeds a target set at 40% of the potential biomass that would be produced under conditions with no anthropogenic disturbance due to fishing, water quality or barriers to migration.

Each Member State is required to

1) Set management targets based on an assessment of potential silver eel production under conditions of no anthropogenic mortality and high (pre 1980) levels of recruitment.

2) Estimate the present day silver eel production in relation to this target (i.e. estimate compliance with the management target).

3) Develop and take the management actions that are necessary to achieve or maintain compliance.

4) Collect data sufficient to support steps 1 to 3 above, and to demonstrate whether compliance will be achieved in the future, i.e. that the actions identified in the EMP will lead to the recovery of the eel population.

In the UK the EMPs will be set at the River Basin District (RBD) level, as defined under the Water Framework Directive. The aim of this EMP is to describe the nature of the eel population and fishery in the RBD, to assess whether the stock is meeting its 40% escapement target, and to present management actions that will ensure the long-term viability of the eel population.

1. Description of eel management units

1.1. Eel Management Units

This plan covers eel management in the Scotland River Basin District (RBD), as defined under the Water Environment and Water Services (Scotland) Act 2003 (Designation of Scotland River Basin District) Order 2003 (http://www.opsi.gov.uk/legislation/scotland/ssi2003/20030610.htm) (Map 1). Scotland River Basin District is regarded as the eel management unit of the Eel Management Plan (Table One), although in some cases data from sub-divisions of the RBD are presented.

Eel Management Units	Bodies Responsible for the Implementation of the EMP
Scotland River Basin District	Marine Scotland (MS) Scottish Environment Protection Agency (SEPA) Scottish Natural Heritage (SNH)

Table 1. List of Eel Management Units contained within the Eel Management Plan, together with the bodies responsible for its implementation

Scotland RBD is situated entirely within the United Kingdom. It includes the whole of Scotland excepting catchments draining south from the main watershed of the Border Hills. These latter catchments are designated as part of the Solway Tweed RBD under The Water Environment (Water Framework Directive) (Solway Tweed River Basin District) Regulations 2004. In addition, a small part of the Northumbria RDB (designated under The Water Environment (Water Framework Directive) (Solway Tweed River Basin District) Regulations 2004) lies within Scotland. The Solway-Tweed RBD will be predominantly the responsibility of the Environment Agency (England and Wales), though Scottish Environment Protection Agency (SEPA) will contribute as required. Eel Management Plans for both the Solway Tweed RBD and the Northumbria RDB are being produced by the Environment Agency.

There are a number of public bodies associated with fisheries in Scotland RBD. These include the Scottish Environment Protection Agency (SEPA, with responsibility for implementing the Water Framework Directive), Scottish Natural Heritage (SNH, responsible for conservation of the natural environment), Marine Scotland (MS, the fisheries authority of the Scottish Government), the Fisheries Trusts (a series of regional charities with a remit to promote freshwater fish, but with as yet incomplete coverage of the RBD), District Salmon Fishery Boards (DSFBs) and the Scottish Fisheries Co-ordination Centre (SFCC, which stores the data collected by the Fisheries Trusts and maintains standards of data collection via training).

2. Description of Scotland River Basin District (RBD)

2.1 Scotland RBD

The geographical extent of Scotland RBD is shown in Map 1. The RBD lies entirely within the United Kingdom.

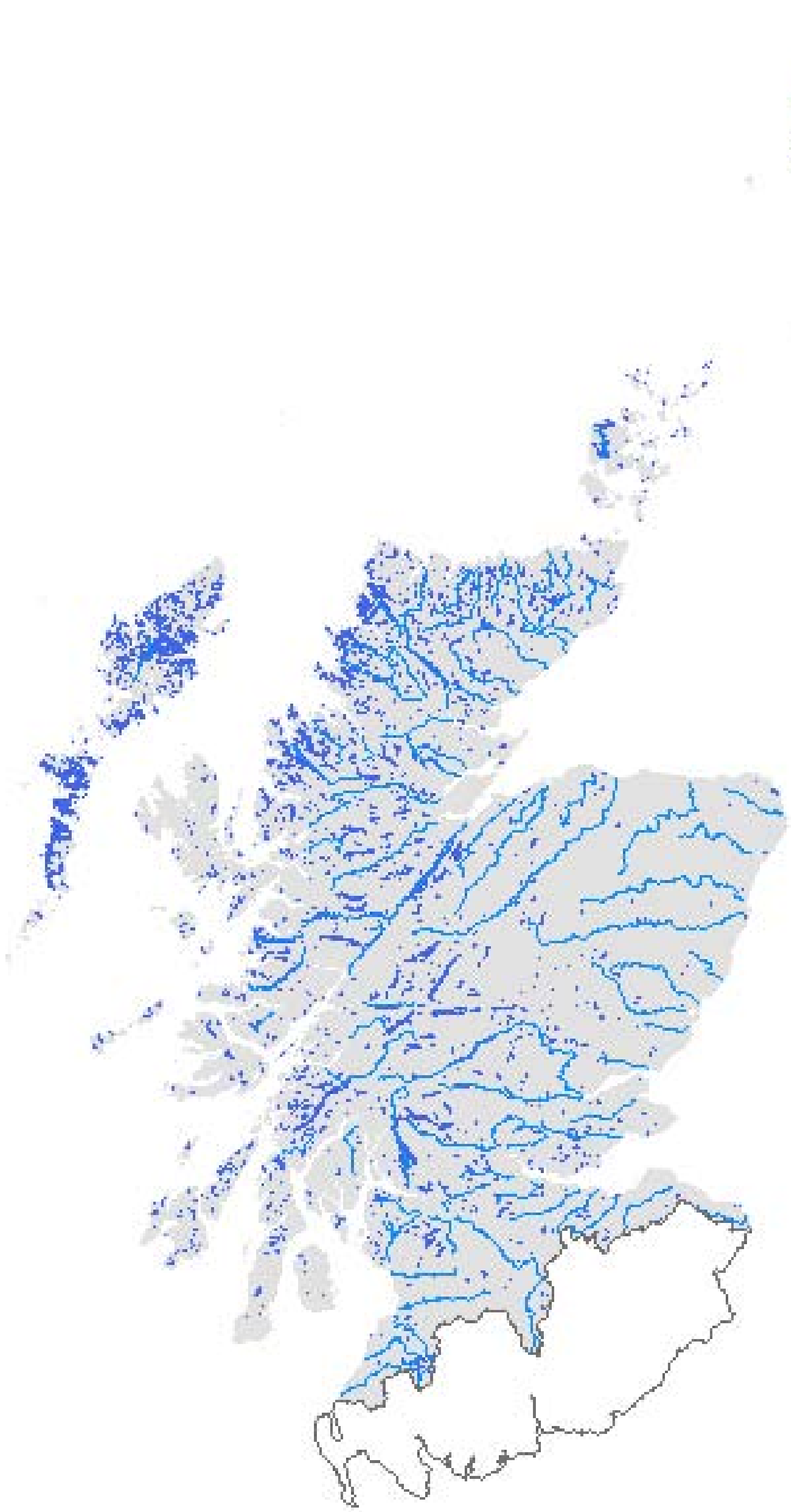
Coastal and transitional waters are not to be managed within the EMP. There are in any case no known fisheries for eels operating within these waters.

Scotland RDB covers approximately 113,920 km^2 of land and water, and includes 39 defined individual drainage basins (as defined for the Water Framework Directive). The total extent of freshwater in Scotland RBD is estimated, using GIS, to be 186,661 hectares, comprising 138,557 ha of standing freshwater (i.e. lakes) and 48,104 ha of flowing freshwater (i.e. rivers).

Within Scotland RBD there are over 100 individual catchments, with a range of catchment types, from the heavily modified to the essentially pristine. Accordingly it is not possible to describe each catchment in detail, and only a general overview is given here. A clear divide within the RDB is formed by the Highland Boundary Fault, which runs on a NW-SE axis from Aberdeen to Arran, and which separates the base-poor Pre-Cambrian and tertiary volcanic rocks in the north west, from more base-rich sedimentary geology (Devonian and Carboniferous) to the south east. Much of the mountainous area of the North West is entirely free of drift geology, while elsewhere boulder clays are the principal surface deposit, with mountain peat forming large deposits in the far north. Rainfall varies across the RBD from west to east with typically 150cm per annum in the west highlands and around half that on the east coast. Rainfall levels are relatively invariant with season across the region, although April to June tends to be the driest time.

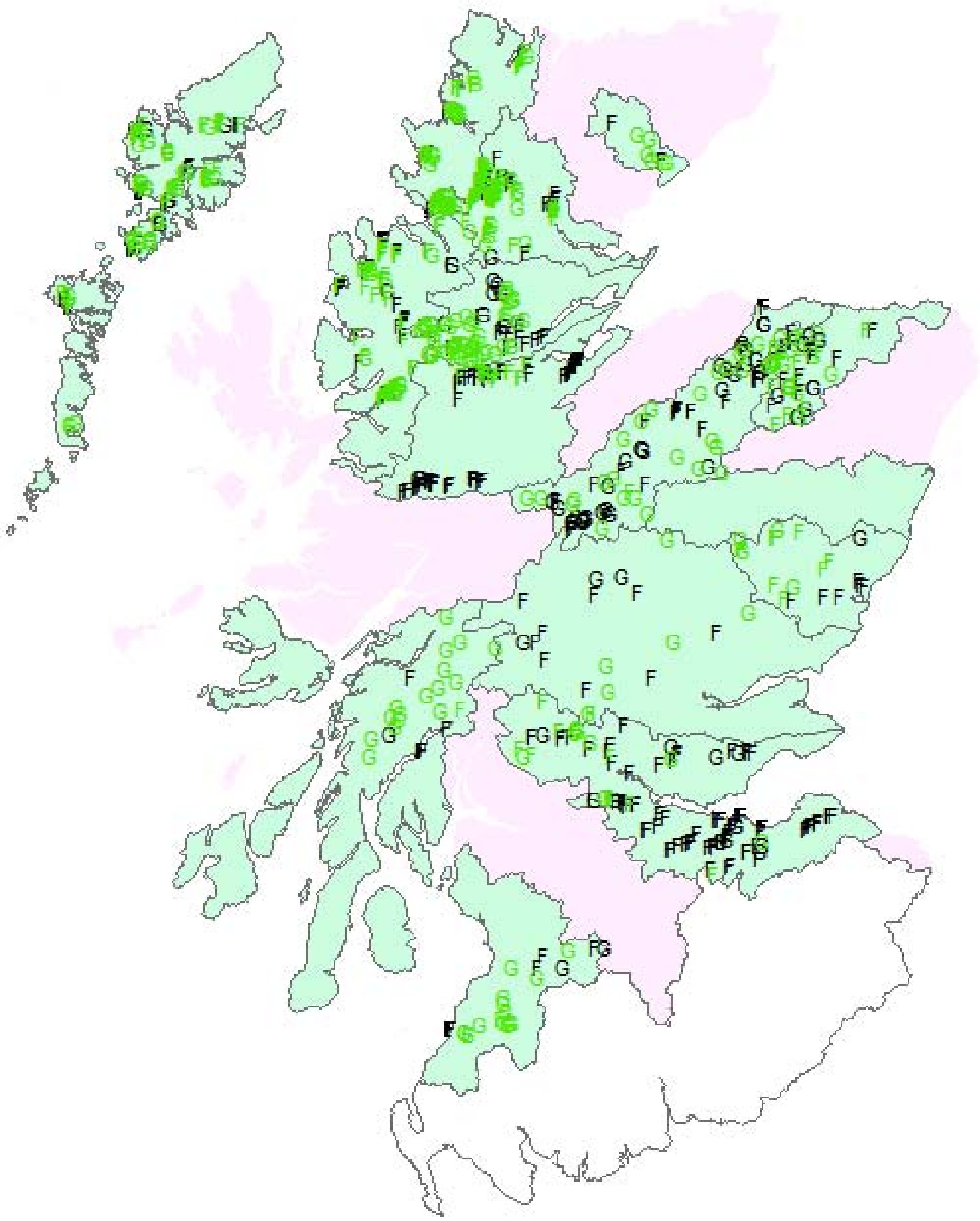
Catchments to the south of the Highland Boundary Fault drain more densely populated areas and so tend to have been (and continue to be) more heavily influenced by human activity (industrial and agricultural) than those to the north, but water quality throughout the RBD is generally regarded as high (see section 2.5). Rivers draining the Highlands are often regarded as the least modified in the U.K., but even in this region there have been dramatic post-neolithic land-use changes (principally deforestation). In addition many rivers in the Highlands have been harnessed for the production of hydro-electricity and so have heavily modified flow regimes. The first major hydroelectric station was opened in 1930 and the principal period of construction was completed by 1965.

Scotland RBD has relatively few heavily modified rivers, but hydroelectric schemes are present in some major systems, whilst weirs and locks can be found in others and these are likely to present major barriers to eel movements, although as yet no specific information about barriers to eel movements is available. Detailed information on barriers to fish migration generally in Scotland RBD is limited, being patchy in extent and of differing levels of detail where it is available. The areas for which data are presently available cover approximately 80% of the RBD (Map 2). These data were initially collected by the Fisheries Trusts in 2002 and were updated in 2007 (Ross Gardiner, Marine Scotland Science) with barriers to salmonid migration being the focus of the collection, and the basis for the definition of the types of barriers. These were divided into several types but have been amalgamated here into four classes, “manmade, impassable” (=MI), “man-made, passable under certain conditions” (MP), natural, impassable” (NI) and “natural, passable under certain conditions” (NP) (see Map 2). Map 3 has a wider spatial coverage, and shows recognised barriers in Scotland RBD deemed to be either passable or impassable to salmonids.



Map 1. Scotland River Basin District, showing principal freshwater bodies and rivers. The shaded area represents Scotland RBD while the outlined blank area shows Scottish territory not included in Scotland RBD.

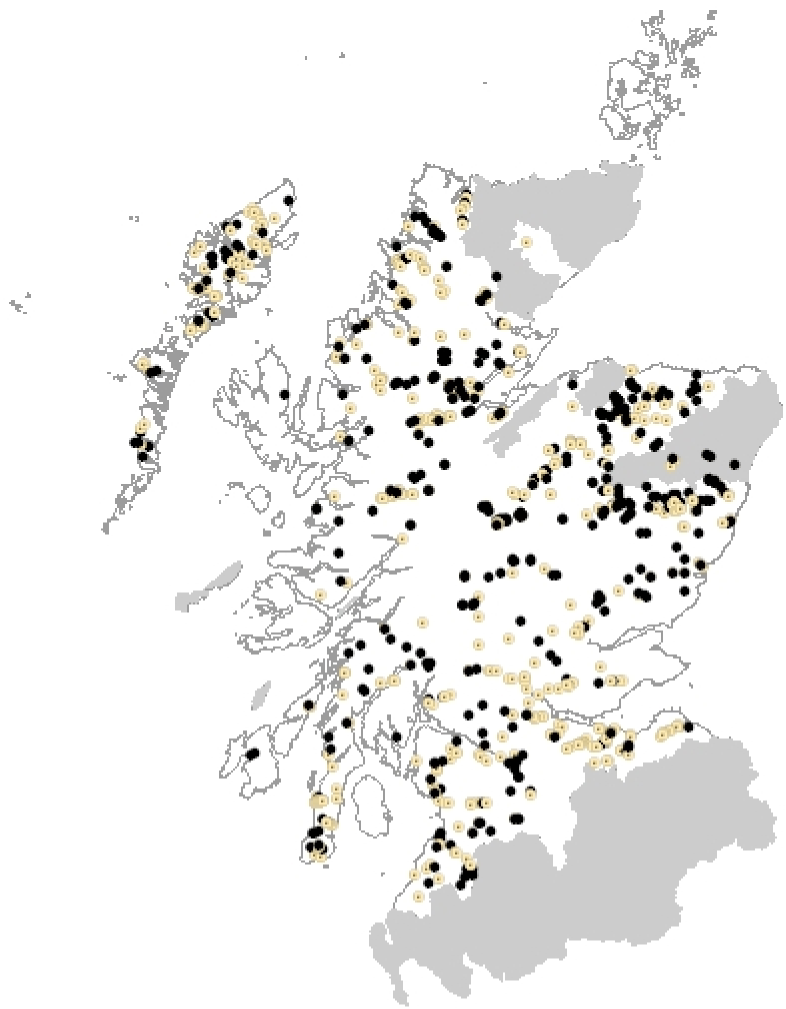
More details of water management issues in Scotland RBD in the form of SEPA reports can be downloaded here http://www.sepa.org.uk/publications/wfd/index.htm



Barriers to fish movements

G	Manmade, impassable
F	Manmade, passable
G	Natural impassable
F	Natural, passable

Map 2. Barriers to fish migration in Scotland RBD. Data only available for those areas shaded.



Map 3. **Manmade barriers to fish migration in Scotland RBD. Dark circles defined as impassable for salmonids, pale circles defined as passable for salmonids. No barrier data were available for shaded areas.**

2.2. Present Status of Eel Stocks

Data

The absence of regulated eel fisheries in Scotland makes for a concomitant lack of high quality data on stock and trends in stock. In particular, there is a dearth of time series data covering the crucial period of the recent general European decline. The only documented assessment of eel stocks in the last 40 years is a report commissioned by the Highlands and Islands Development Board to investigate the potential for establishing an eel fishery in the Highlands (Williamson 1976). Various lochs were fished by hired fishermen over the period 1973-1976 using Dutch fyke nets or baited pots in a standard, repeatable way. Although the amount of effort put into each loch was determined by the fishermen themselves (who were able to sell their catch for profit), the method of fishing, the number of nights fished, and the number of fyke nets or baited pots set per night were all recorded, and the total catch expressed in terms of weight. Additionally 584 eels were aged from otoliths and their individual lengths are recorded in the report. Unfortunately there are no recent data with which to compare these values. Williamson concluded that the density of eels was too low, and their growth rates too slow, to permit profitable full-time commercial eel fishing in the Highlands

The establishment of Fisheries Trusts and the Scottish Fisheries Co-ordination Centre has allowed the collation of a number of electrofishing surveys, which now represent the principal source of information. The earliest of these data are from 1996, but spatial coverage is adequate only from 1997 onwards. It should be noted that there is considerable variation amongst the reports from individual Trusts in the level of detail that was recorded. Some of the data used here were collected with funding from SNH and remain their property, otherwise all data are the property of the relevant Fisheries Trusts. Both SNH and the Fisheries Trusts have kindly allowed their use here. There are substantial areas of Scotland RBD for which data are not available, including the catchments of the Clyde, the Don, the Ythan, the Nairn, the Ugie, as well as the entire islands of Skye, Orkney and Shetland, (these latter two island groups are omitted from most maps for reasons of space and clarity).

There are a number of problems with the interpretation of these data.

1) The surveys were not targeted at eels; instead the data are derived from a by-catch of a sampling programme aimed at assessing salmonid densities.

2) Work sheets and database tabs have spaces for eels, but it is possible that some of the sites in which eels are recorded as absent could represent a failure to record data. The level of this type of error (if it occurs at all) is likely to vary between areas, and may be significant.

3) Even when directly targeted at the species, electrofishing for eels is an inexact science, and density estimates should be regarded with caution. Observed densities are likely to be size and habitat (in particular substrate) dependent, and no attempt has been made to account for this.

4) The data set is comprised of different types of electrofishing: multi-pass (22.9%), single-pass (69.5%), and timed fishings without delineated areas (7.6%).

5) In most cases the numbers of eels caught were in any case not recorded directly, but allotted to abundance classes (Absent, 1-10, 11-100, 101-1000). For some Trust areas the exact number of eels was routinely reported. In others the exact number was only occasionally reported, with potential for bias (of unknown size or direction).

6) In most cases the size of eels was not reported. For some Trust areas length of eels was routinely reported, in others the lengths of eels were only occasionally reported, with potential for bias (of unknown size or direction).

7) Where eel lengths were recorded individual eels were sometimes described as ‘silver’, but it is not known how often (if ever) the lengths of eels were recorded and their maturity status overlooked.

In an attempt to standardise these disparate fishing types as much as possible, the following assumptions were made. Based on the average decline in capture rates of eels in three-pass fishings (where they were recorded), the likely result of a single-pass fishing was calculated for the remaining three-pass and two-pass fishings. Based on a negative binomial distribution of the observed data, the mean value expected for each class of eel number (1-10, 11-100, 101-1000) was calculated. This number, or the exact number if recorded, was used to calculate density by dividing it by the reported area of the site fished. For timed fishings (<4% of the total fishings), the area was estimated from the time fished (based on the relationship between time and area fished from a sub-sample of sites in which both parameters were recorded). A few timed fishings (n=445 or 0.67% of fishings) had neither time nor area associated with them, and these were assumed to have the same area as the mean of the other timed fishings. In this way all the fishings were converted to the same units (number of eels $100m^{-2}$ in a single-pass fishing).

There are a number of assumptions inherent in the treatment of the data described above

8) that the sample for which capture rates of eels on all three runs were reported was representative of all fishings (i.e. that the decline in capture rates is constant across fishers and habitats)

9) that the sites for which exact numbers were recorded were representative of sites for which the number of eels was estimated only to a class size category

10) that ‘timed’ fishings for which no time was recorded were of a similar duration to average duration of timed fishings where the time was recorded.

All these assumptions are likely to be violated to some extent, compromising the confidence that can be placed in the density estimates. While absolute values should be treated with extreme caution, and even presence/absence data may be unreliable, these data may nevertheless have internal consistency and so be informative about temporal trends.

2.2.1 Glass eel stocks

There are no data available regarding numbers or distribution of glass eels in Scotland RBD.

2.2.2 Distribution of yellow/silver eels

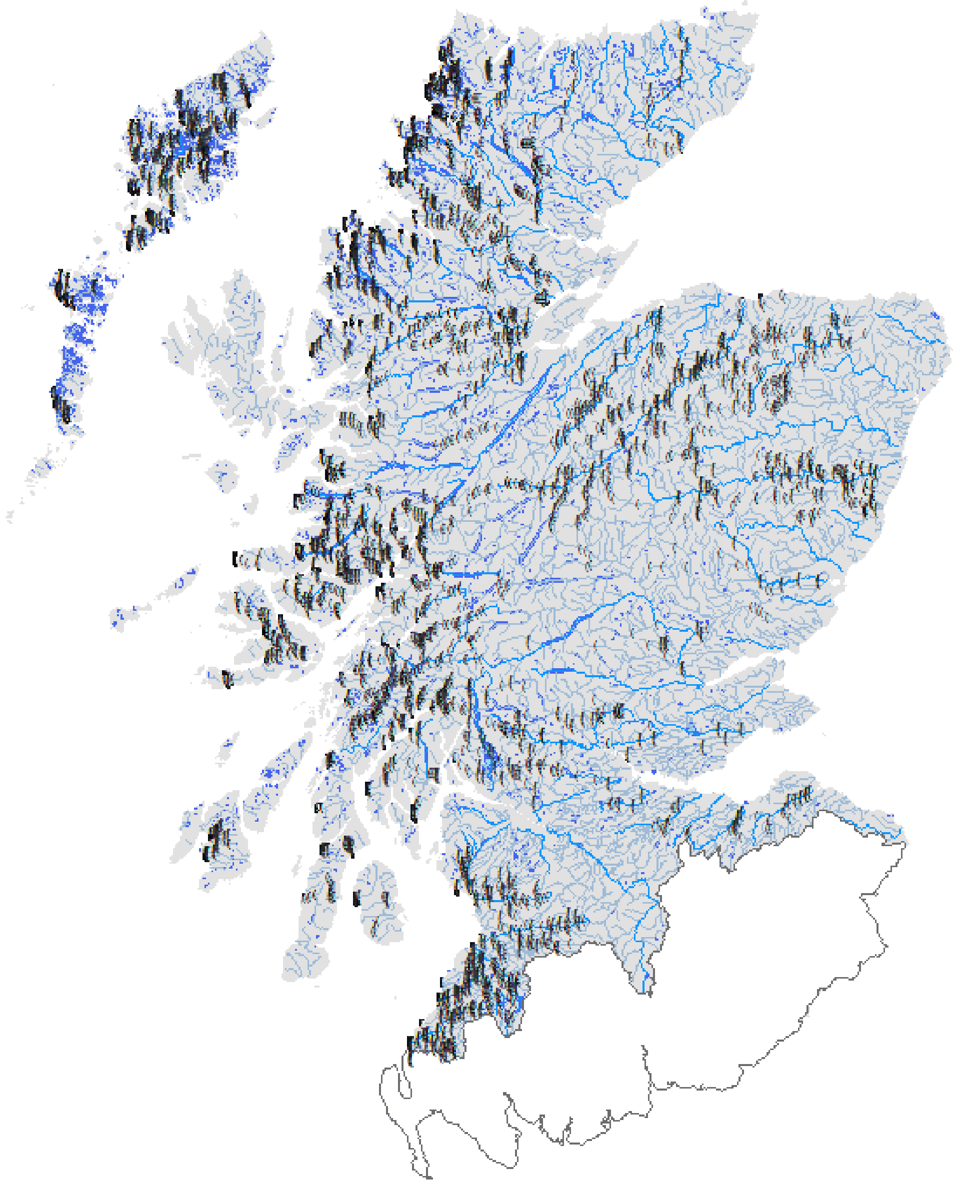
Freshwater

The presence or absence of eels reported from all sites electrofished by the SFCC/Fisheries Trusts between 1996 and 2006 is shown in Map 4. A total of 6651 electrofishing visits were made to 3645 sites. Eels were present at 39.7% of visits, and recorded as present on one or more visits at 44.3% of sites. There are substantial regions of Scotland RBD for which no data were available (Map 4) but eels are widely distributed in the documented areas.

Over the course of the period for which data exist there was no evidence for a change in the percentage of sites where eels were reported as absent as might be expected in a period of ongoing declines in recruitment (ICES 2006) (Table 2, Fig. 1). The first year for which data were available has the lowest percentage of sites where eels were found to be present, but this likely reflects the limited spatial extent of the data in 1996 (see Appendix A). Thereafter the distribution of eels appears essentially unchanged. On average eels were absent from about 60% of sites that were fished in Scotland RBD.

There was considerable spatial variation in the distribution of eels, with eels being much less likely to be absent from sites in the north western parts of Scotland RBD. In the Western Isles, West Sutherland and Wester Ross eels were absent at approximately 20% of sites, compared with 55% in Scotland RBD as a whole (Fig 2, Table 3). This probably reflects the proximity of the north west of Scotland RBD to the continental shelf (Knights *et al* 2001).

It is evident from Map 4 that eels were less likely to be present at sites further from the coast. Information about the distance of the electrofishing sites from the coast is not available but densities declined exponentially with altitude (Fig. 3) and, above 100m, eels were recorded at relatively few sites (although eels were also found at sites above 500m altitude). It is unknown whether these trends reflect natural or man-made barriers to movement, or whether this distribution reflects the outcome of unhindered density dependent movements.



Map 4. **Eel presence (●) or absence (◦) for sites electrofished in Scotland RBD between 1996 and 2006. Where sites were visited more than once, eels appear as present if they were reported at the site on any occasion.**

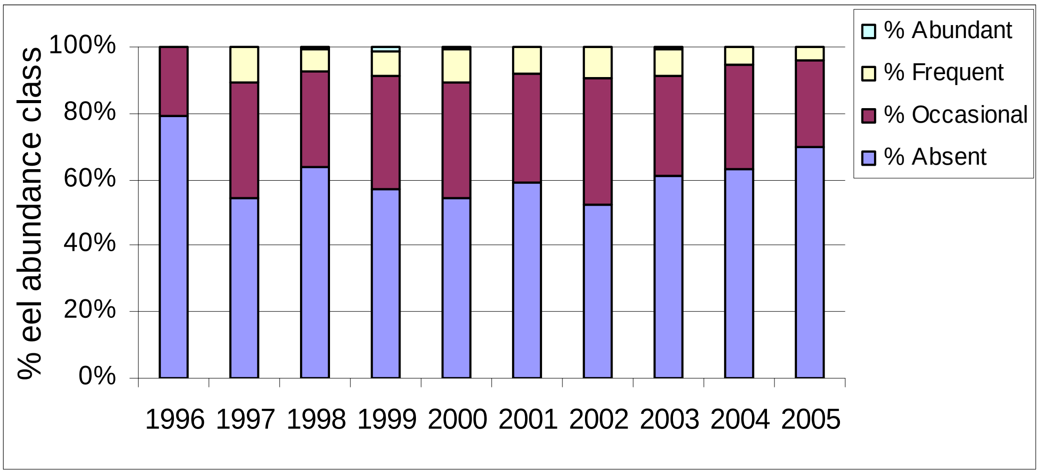


Figure 1. **Eel presence/absence and abundance classes in Scotland RBD, 1996-2005. All site visits are included, site visits and contribution of different areas to the Scotland RBD total varies; in 1996 only 19 sites were fished, all on the Spey. Abundance classes as follows: Absent=0 eels, Occasional =1-10 eels, Frequent =11-100 eels, Abundant = > 100 eels.**

Area	Number of sites with eels				Total
	Absent	Occasional	Frequent	Abundant	
Argyll	336	168	33	4	541
Ayrshire	164	146	42	6	358
Beauly	16	10	5	0	31
Berriedale	5	4	0	0	9
Conon	150	25	7	1	183
Dee	101	56	5	0	162
Deveron	91	19	1	0	111
Findhorn	46	27	1	0	74
Forth	91	41	5	3	140
Kyle of Sutherland	182	17	4	0	203
Lochaber	238	150	51	2	441
Lomond	33	24	0	0	57
Naver	3	4	1	0	8
Ness	15	0	0	0	15
South Esk	6	4	1	0	11
Spey	111	96	9	0	216
Tay	35	7	0	0	42
Thurso	4	6	1	0	11
West Sutherland	72	109	57	5	243
Wester Ross	32	111	35	0	178
Western Isles	47	150	83	0	280

Table 2. **Number of electrofishing sites for various catchments or districts of Scotland RBD, 1997-2006, together with the abundance class of eels recorded. Where sites had multiple visits the visit with the highest reported abundance class appears. Occasional = 1-10 eels, Frequent=11-100 eels, abundant=>100 eels**

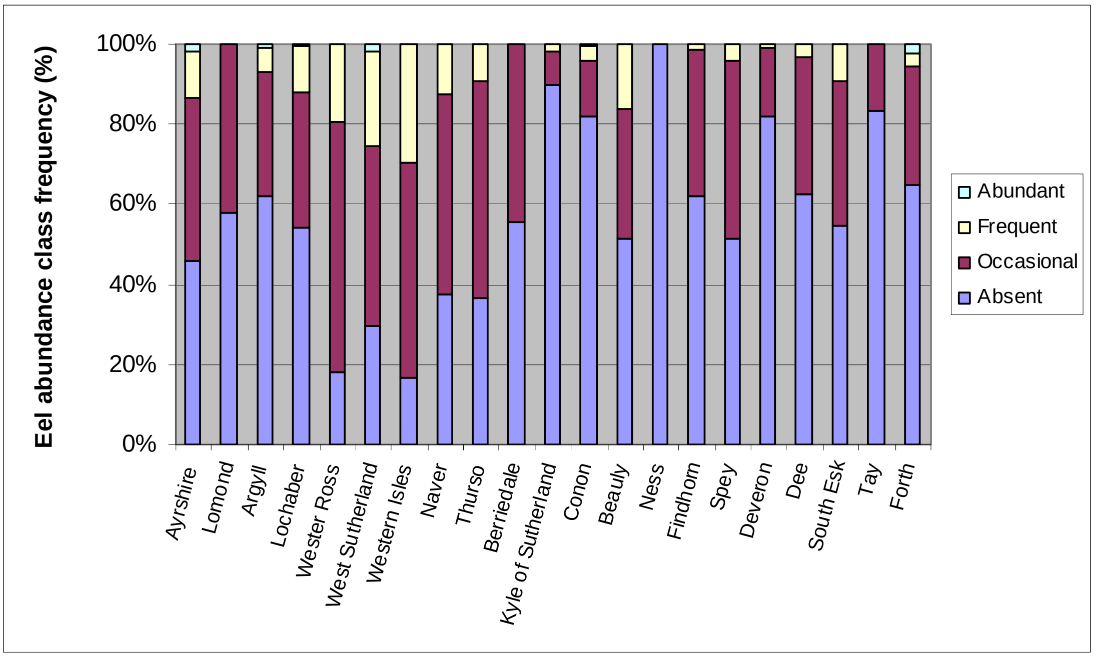


Figure 2. **Percentage frequency of eel abundance class at electrofishing sites in various rivers or districts of Scotland RBD. Areas are arranged clockwise around the coast, from Ayrshire in the south-west, to Naver and Thurso on the north coast then down the east coast to the Forth region. Where more than one visit to a site was made the highest recorded abundance class was used. See Table 2 for sample sizes. In general eels were more widely distributed and more common in the north-west and north.**

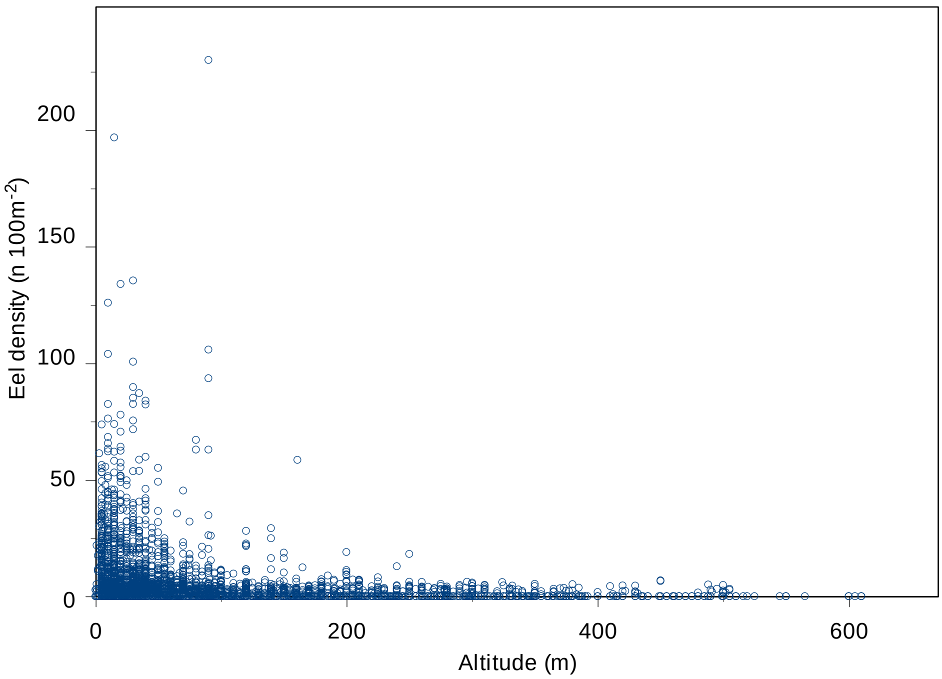


Figure 3. **Relationship between eel density at electrofishing sites (1996-2006) and altitude, Scotland RBD.**

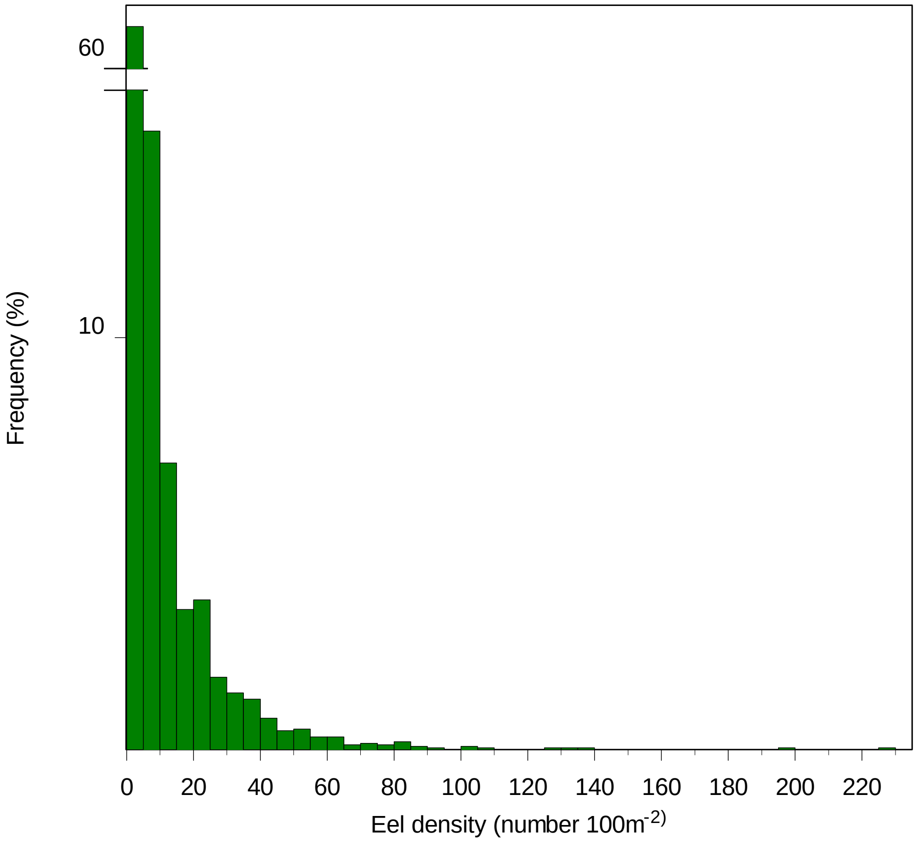


Figure 4. **Distribution of eel densities (excluding surveys where eels were absent) as percent frequency of occurrence from single-pass electrofishings in Scotland RBD. Note axis break.**

Marine/Estuarine eel stock

There are no data available regarding marine or estuarine eels in Scottish waters, other than that they were caught at each of seven sites fished in 1974 (Williamson 1976).

Stock abundance

The densities described here are minimum density estimates as derived from single pass fishings and should be regarded as approximate (see above). Eel lengths were routinely collected in the Wester Ross region and on the River Dee catchment, but, at best, only on an occasional basis elsewhere in Scotland RBD. Accordingly, this report has focused on density estimates for which more widespread data were available.

Density and biomass

Eels were absent at 60.3% of site visits. The estimated densities for the remaining 39.7 % of visits in which at least one eel was present are shown in Fig 4. The median density was 3.66 eels100m^{-2} and the back-transformed mean was 4.33 eels 100m^{-2}. The maximum estimated density was 230 eels 100m^{-2}**.** Within Scotland RBD there was significant regional variation in the reported densities with higher densities prevalent in the West Sutherland and the Western Isles ($P<0.001$, Appendix A). Where eels were present the distribution of densities was in the form of a negative exponential being dominated by low densities (with over 60% having densities of <5 eels 100m^{-2}) (Fig 4).

These densities are about an order of magnitude lower than target densities for English rivers developed by Knight & White (1998), but it should be recalled firstly that they are single-run minimum density estimates rather than true densities and that the electrofishing was not targeted at eels. Additionally the cold oligotrophic waters of Scotland RBD would be likely to have typically lower values than southern waters that are more conducive to settlement and survival. We were unable to compare the Scotland RBD data with the Reference Condition Model (ICES 2003), because of insufficient data on yellow eel densities along river courses.

Historical information on the density of yellow eel populations in Scotland is rather scarce. Prior to the establishment of a barrier to upstream migration, densities were 16 eels 100m^{-2} on the Girnock Burn (tributary of the Dee, 70km from the coast: altitude 250-350m). Since the establishment of the barrier, densities have fallen steadily to 3.1 100m^{-2} in 2004/5 (Chadwick *et al*, unpublished data). Another Dee tributary, the Dinnet Burn (altitude 150-200m), had densities of 10-16 eels 100m^{-2} in 1994 (Carss *et al* 1999). Mills & Hussein (1985) reported mean densities of 8.5-8.8 eels 100m^{-2} on sites fished in 1977 and 1984 on the river Tweed (just to the south of Scotland RBD).

There is some weak evidence that eel densities in Scotland may have declined over the last few years (post-2000) amongst all sites fished (Fig 5). It is possible that this is a spatial rather than a temporal effect, however, because the distribution of sites differed between years, both locally and regionally (see Appendix A). To control for this the same analysis was conducted using the data only from those sites with samples in at least five of the years (Fig 6), and a weak downward trend in eel density from 2004 onwards was indicated. This pattern was evident for several individual regions of Scotland RDB (Fig 7). The pattern was not universal however, with West Sutherland in the North West of the RBD particularly showing a general trend for an increase in population density.

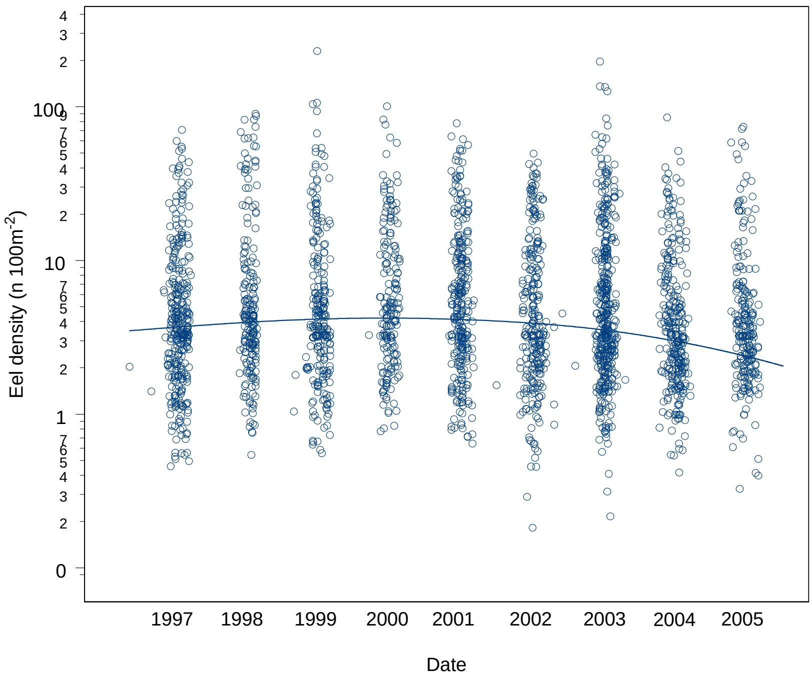


Figure 5. Eel density (log scale) from all electrofishing sites between 1997 and 2005. Smoothing spline fitted with 3 degrees of freedom suggests a slight decline in density post 2002, however, different regions of Scotland RBD are not equally represented in each year (see Appendix A for spatial coverage).

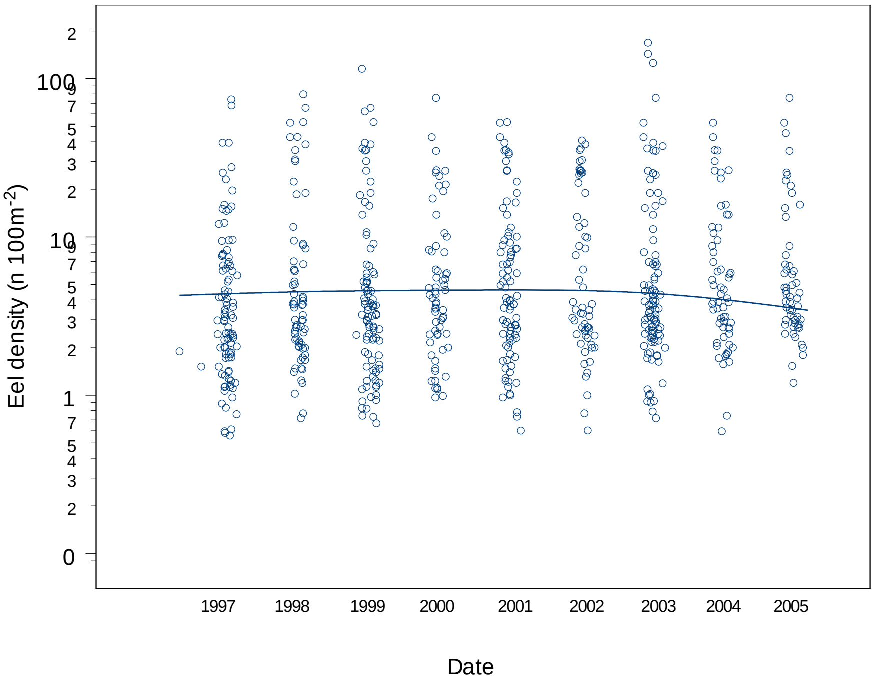


Figure 6. **Temporal variation in eel population density at sites for which at least 5 annual samples were made over the period 1997-2005**

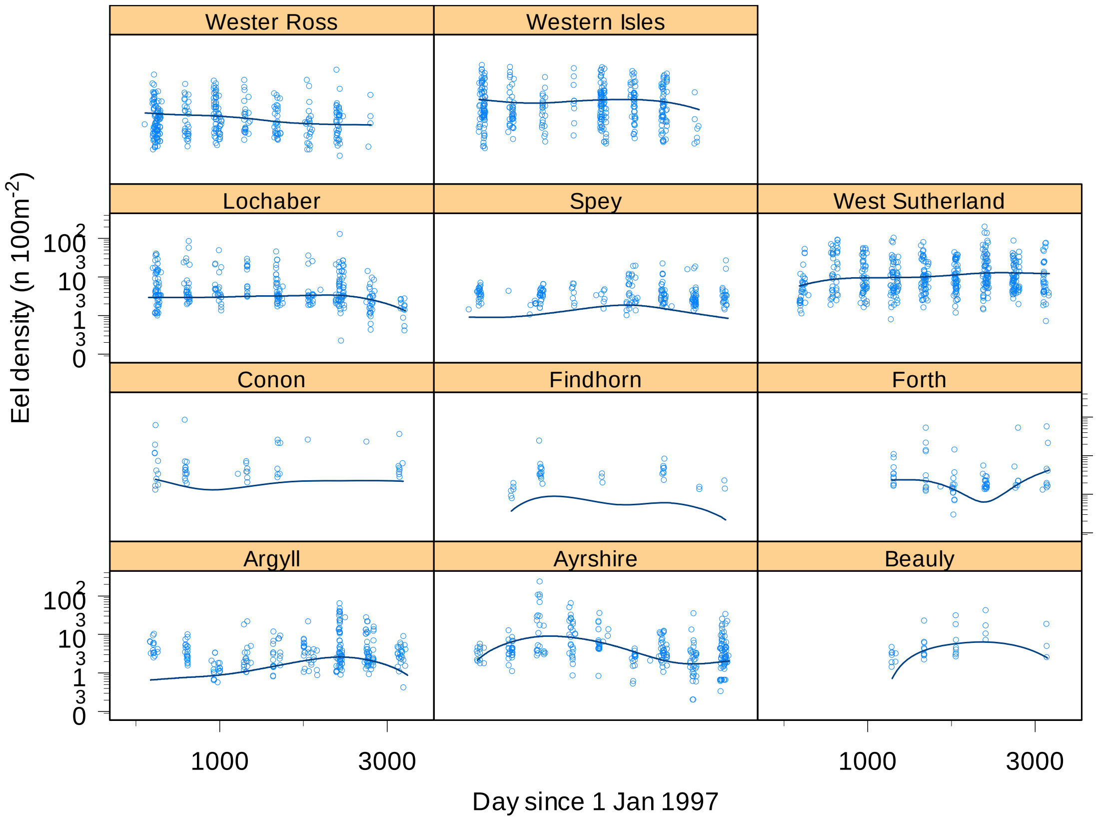


Figure 7. **Temporal variation in eel population density at regional level within Scotland RBD, 1997-2005. Sites where eels are absent do not appear in the graphs, but the lines (smoothing splines with 3 degrees of freedom) are fitted with them.**

A second way of looking at trends in population was developed using just the 285 sites for which there were at least 5 visits between 1996 and 2005, thus controlling for spatial variation between years. For each site Pearson's R value or the correlation between year and population density was calculated. The average Pearson's R value for several regions of Scotland is shown in Fig 8. Overall mean Pearson R value was negative, indicating a downward trend in density. However this did not occur consistently across Scotland RBD, with several areas showing a positive mean Pearson's R value.

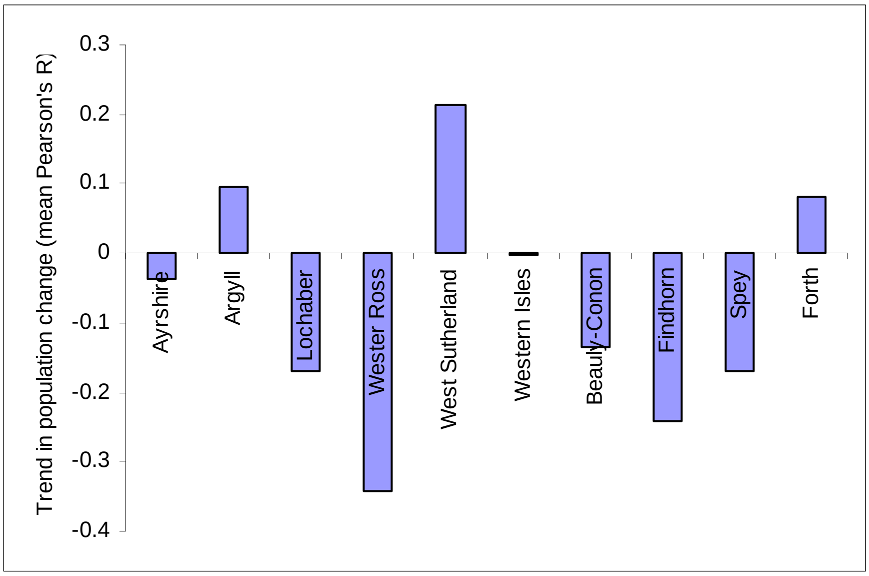


Figure 8. Trends in population density for various regions within Scotland RDB based on sites with at least five visits in the period between 1996 and 2005. Trend in population is Pearson's R value for the relationship between date and population density at each site (arranged clockwise around the coast beginning in the South West. Sample size: Ayrshire n=14, Argyll n=38, Lochaber n=23, Wester Ross n=64, West Sutherland n=49, Western Isles n=13, Beauly-Conon n=6, Findhorn n=13, Spey n=64, Forth n=1)

If the decline in glass eel recruitment has reached a sufficiently low level to influence yellow eel populations, and if movement upstream is a density dependent process (Ibbotson *et al* 2002), then it is predicted that changes in population density would be most prevalent further from the coast. We investigated whether this was the case using site altitude as a surrogate for distance from the sea. Using the data from the 285 sites to which at least 5 visits had been made between 1996 and 2005 we calculated Pearson's R value for the correlation between year and density at a particular site to indicate the trend in population density. This value was plotted against site altitude (Fig 9). We predicted a positive relationship if yellow eel recruitment was declining over the period 1996-2005. However, there was no evidence that altitude was related to trend in population density ($P<0.9$) suggesting that significant temporal change in yellow eel recruitment in Scotland RBD has not occurred over the last ten years.

There are additional data for a single site, at 10m on the Allt Coire nam Con, Loch Shiel, Argyll which has been monitored each year since 1990 (Peter Collen, unpublished data). At this site densities of eels were high in 1990 and 1991 (41 and 30 eels $100m^{-2}$ respectively), but thereafter have averaged 13 eels $100m^{-2}$, with no temporal trend (Fig 10). This isolated survey, aimed directly at eels, aligns with the data of the various

Fisheries Trusts for the period over which they coincide, but raises the possibility that a decline in eel densities may have occurred in the early 1990s, preceding the starting date of the data collected by the Fisheries Trusts by about 5 years. It should be stressed that this survey represents a single low-lying site, and is included separately only because it represents the only available time series dating back beyond 1996 that is not compromised by the establishment of a barrier to migration (as at the longer data set at the Girnock Burn).

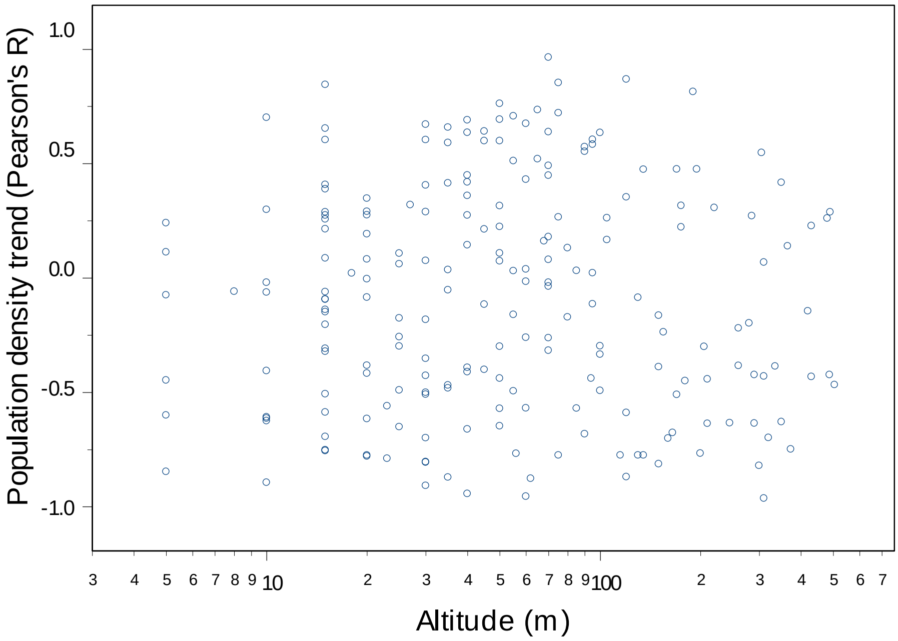


Figure 9. Trends in population density in relation to site altitude (log scale) based on 285 sites with at least five visits in the period between 1996 and 2005. There was no evidence for an altitude effect. Trend in population is measured as the Pearson's R value for the relationship between date and population density at each site.

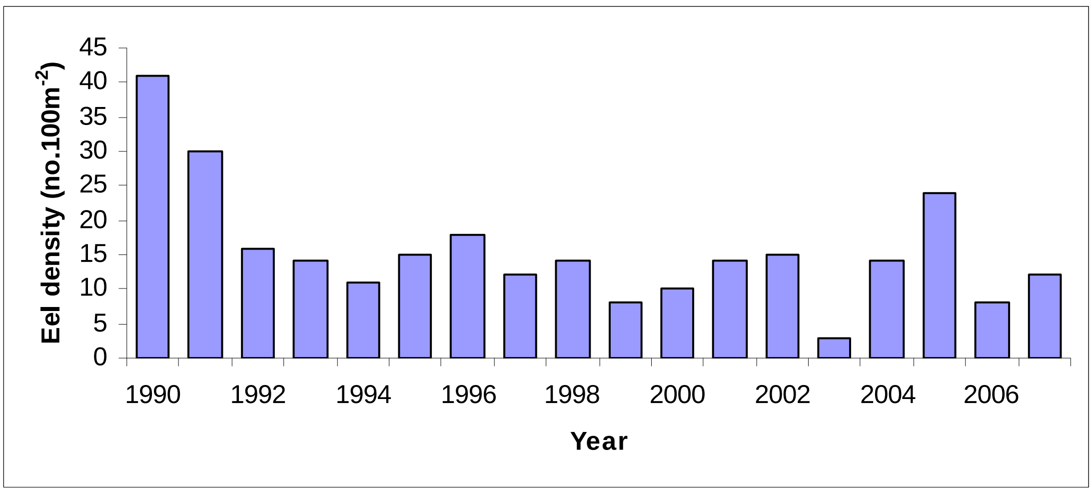


Figure 10. Eel densities from 1990-2007 from a single site on the Allt Coire nan Con, Argyll

Population size structure

The distribution of reported individual eel lengths (n=1136) caught by electrofishing in Scotland RBD in 1996-2005 is shown in Fig 11. This probably represents the size structure of an essentially unexploited population, showing a slight negative skew, and with a noticeably extended right-hand tail of eels longer than 375mm composed, of maturing females (Knights *et a*l 2001). The mean length was 203mm, the median length was 192mm, and modal class was 150-175mm. The mean length of individual eels in this study (203mm) is identical to the mean length of eels recorded at the Girnock Burn prior to the establishment of the upstream barrier. It is substantially smaller than the 234mm reported from the more recent period at the Girnock Burn (Chadwick *et al* 2007) and to the 240mm reported from the Dinnet Burn in 1994 (Carss *et al* 1999). The mean of mean eel lengths at electrofishing sites was significantly larger at 229mm than the mean of all individuals, indicating, as expected, that larger eels tended to be found at lower densities.

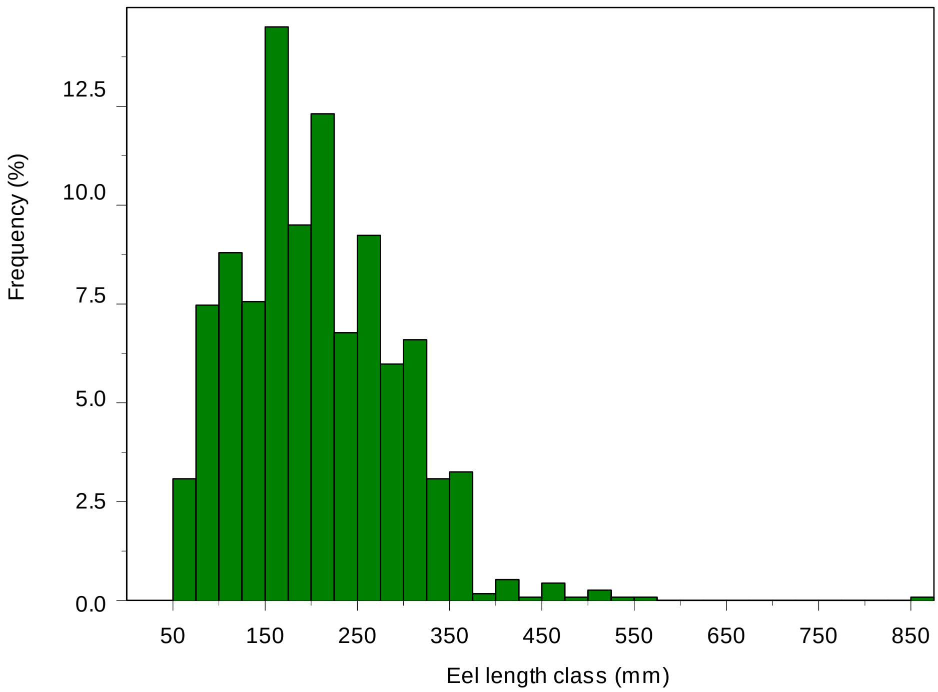


Figure 11. Size distribution of eels caught by electrofishing in Scotland RBD 1997-2005 (n=1136)

There was relatively little variance in reported sizes across the country, although eels from the East were marginally larger on average than eels from the west, in line with the expectations of higher recruitment along the western seaboard (Knight *et al* 2001), although the difference was marginally non-significant (P<0.052) (Fig 12). Dividing Scotland RBD along the fault line of the Great Glen (running between Fort William and Inverness), mean eel length in the North West was 221mm (n=189), in the North East 240mm (n=5), in the South East 251mm (n=74), and in the South West 235mm (n=21). The sites in these areas are not matched, however, and so no robust comparisons can be made between them.

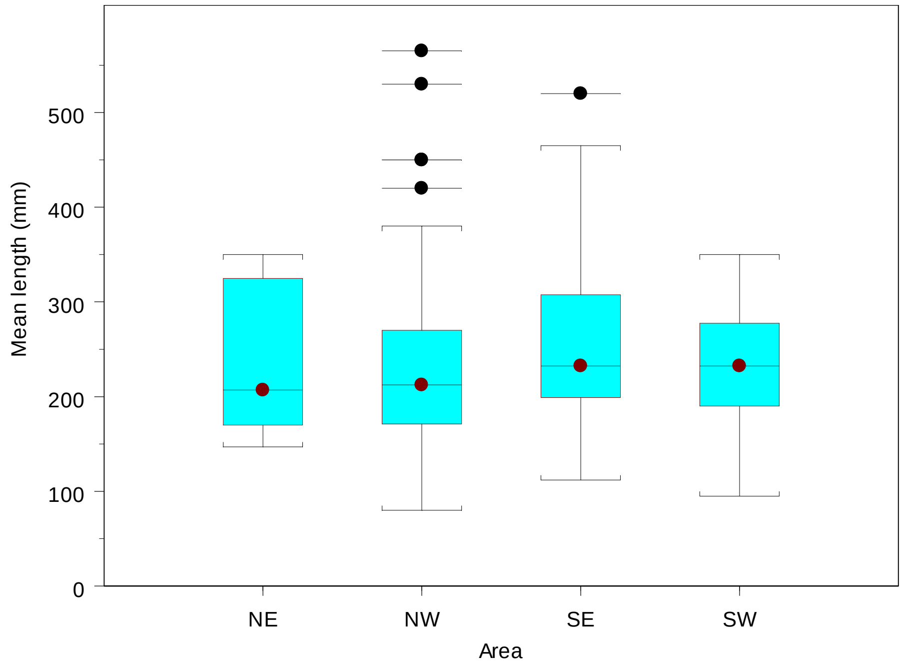


Figure 12. **Mean lengths of eels at electrofishing sites in Scotland (silver eels included). Most data are from Wester Ross and the River Dee. Geographical distinctions based on the Great Glen fault. The box limits show the 25th to 75th percentile range, bars cover the 10th and 90th percentile range.**

A decline in recruitment would be expected to be reflected in an increase in average size, just as low-recruitment rivers are expected to have larger eels than high recruitment rivers (Knight *et al* 2001). Some unpublished data from the Girnock Burn (Chadwick *et al* 2007) charts the possible effect of an introduction of a partial barrier to upstream movement on a small stream. Mean length of eels above the barrier rose rapidly from 203mm to 228mm after 14 years but thereafter only to 234mm after a further 23 years. Based on this information the period of data for which eel lengths are available, (1998-2005) would probably be too late to detect the potential impact of a collapse in recruitment in the early 1980s on size structure. However the European decline in glass eel recruitment is ongoing (ICES 2008), so a general trend towards increasing size would still be predicted if glass eel recruitment were affecting yellow eel recruitment in Scotland RBD. However, there is little evidence for a change in mean eel length either in the RBD as a whole from 1997-2005 (Fig 13, slope does not differ significantly from zero) or amongst the only region of the RBD for which detailed information is sufficient to judge, Wester Ross, (Fig 14, ANOVA of differences between years P=0.9). In particular these data do not show the decline in the abundance of the smaller size classes that would be anticipated if the decline in glass eel recruitment was affecting the standing stock of yellow eels.

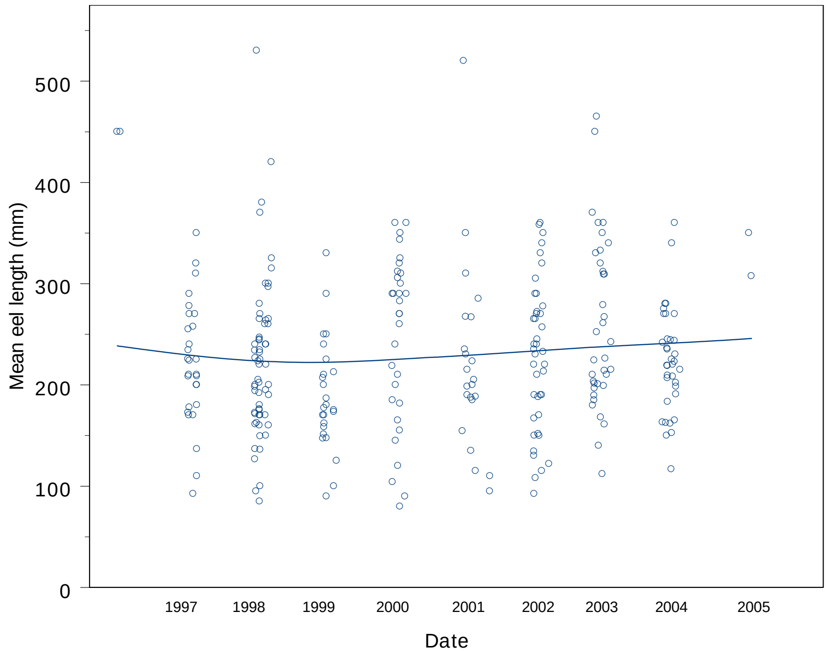


Figure 13. Mean length of eels caught at electrofishing sites in Scotland RBD 1997-2005 (n=1136). Linear regression slope does not differ significantly from 0, P<0.8).

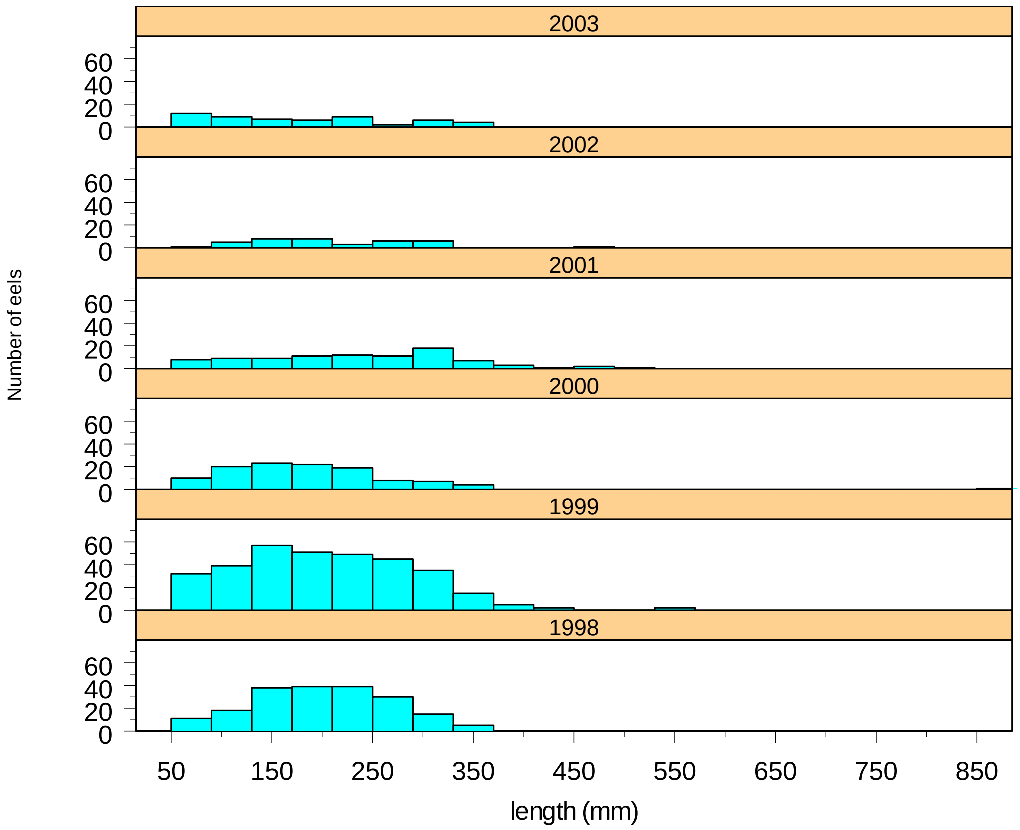


Figure 14. Length distributions of eels caught by electrofishing in Wester Ross, 1998-2003. The overall mean length was 200mm, and length did not differ between years (P<0.9)

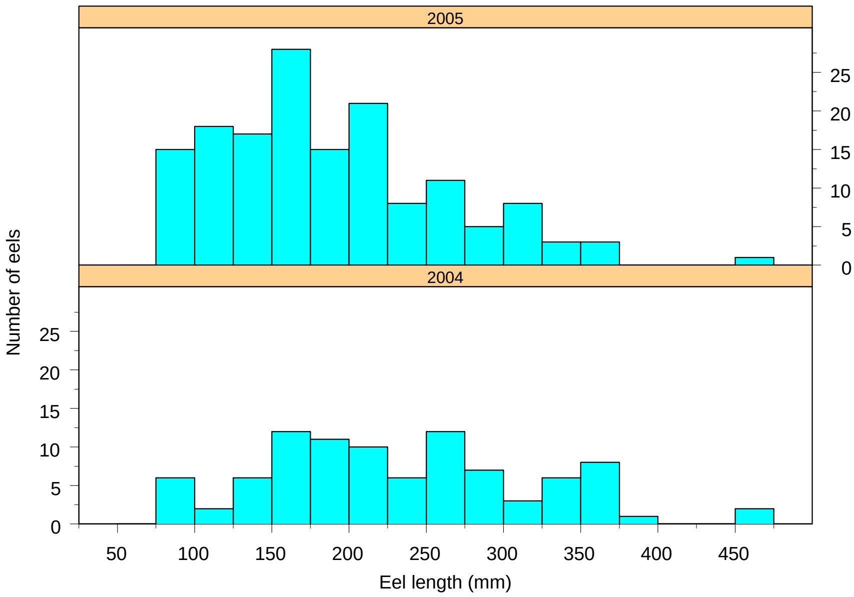
The difficulty of interpreting such data however is illustrated by reference to Figure 15 a) & b). Looking at the eel length data from all electrofishing sites on the River Dee in 2004 and 2005, there is a significant difference in the distributions (ANOVA P<0.001) with means of 231mm in 2004 and 187mm in 2005 (Fig 15a). Inspection of the distribution reveals an apparent influx of eels with smaller length classes, as if following a previous high-recruitment year. However, by restricting the data selection to sites that were fished in both years this apparent temporal effect is shown to be a spatial effect (Fig 15b).

One likely component of this spatial effect is the altitude of the electrofished sites. Across Scotland RBD there was a consistently significant positive relationship between altitude and mean length of eels at a site (Fig 16). This probably results from increasingly high proportions of older, larger eels further from the sea (Knight *et al* 2001).

Freshwater growth rates have not been widely assessed in Scotland, but have been estimated at 13mm per year based on 10 individuals by recapture at the Girnock Burn (Chadwick et al unpublished data), with the range of individual growth rates being from 9mm to 17mm per year. Updated estimates at this site, based on 28 individuals for whom periods of at least one year of growth was available, has estimated growth rates at 11.6±1.3 mm yr^{-1} (Marine Scotland Science, unpublished data. Similar results were recorded by Williamson (1976) using otoliths to estimate the age of known length eels. Recently measures of growth rates at a high altitude catchment in Scotland (the Baddoch Burn) have estimated mean growth rates at just 2.94±1.1mn yr^{-1}, based on 7 individuals (Marine Scotland Science, unpublished data). These values are low compared to reported figures for continental rivers, and even for more southerly British rivers (e.g. around 20mm yr^{-1} growth was reported on the Tweed (Mills & Hussein 1985)), although similar values (14mm per year) have been recorded in the Burrrishole catchment in Ireland (Poole & Reynolds 1995). Assuming elvers are 70mm at the start of their pigmented stage, the Girnock Burn growth rates suggest that after 20 years the fastest growing should be 410mm (and therefore likely to have emigrated, if male, and be close to emigration if female). The average growers would be expected to be 302mm after 20 years (approximately the size of the smallest male silver emigrants) but still many years from reaching a typical size for a female silver eel. The slowest growing individuals should be 250mm after 20 years, and hence still likely to be present in the river whether male or female. The slowest growers could still be present in Scottish RBD as many as 50 years after elver recruitment, while the ultra-slow growth rates on the Baddoch Burn suugest the possibility that very old (> 100 years of age) are present in the system. Thus Scotland RBD is likely to be unusual in Europe in representing a repository of eels for which recruitment pre-dates the declines from 1979 onwards.

If the European decline in recruitment also affected Scotland RBD, and if the extent of the decline was sufficient for a reduction in yellow eel densities (for which no general evidence can be identified), two predictions should follow: 1) mean eel lengths at freshwater sites in Scotland should have been and should still be increasing as the number of younger eels declines relative to older eels and 2) a decline in freshwater population densities consequent on recruitment declines should be less steep in Scotland than in warmer more productive areas, and still ongoing during the period 1997-2005. However, the available data do not provide support for either of these predictions. Thus, 1) although there has been a very slight increase in reported eel length since 1998, the slope of increase does not differ significantly from zero and 2) the best available data (which are acknowledged to be weak) indicate that if any decline in adult populations has occurred in the last 10 years it has occurred not gradually, but post-2002.

a)



b)

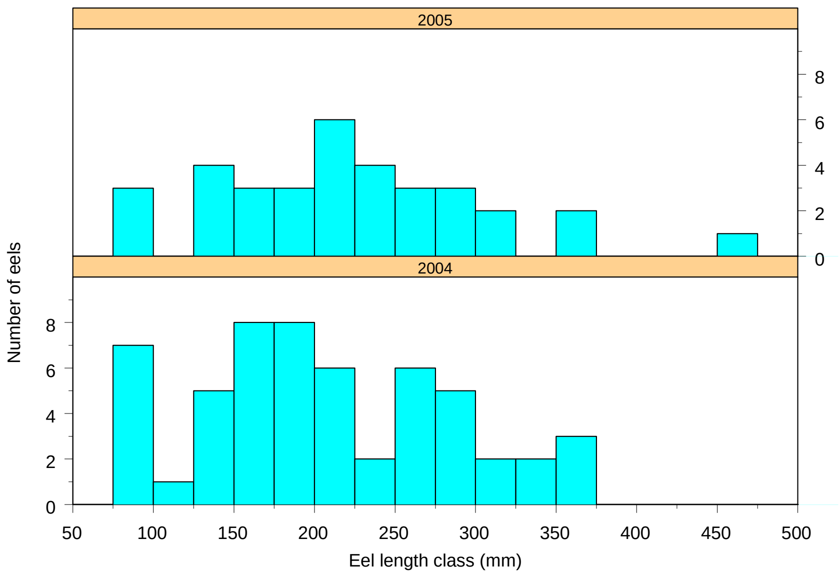


Figure 15. **Reported eel length distributions on the River Dee in 2004 and 2005 .a) Data from all electrofishing visits (n=35 in 2004 and 34 in 2005). The two distributions differ significantly between years (ANOVA, P<0.001). b) Data restricted to the 12 sites which were fished in both years. The distributions did not differ significantly between the two years (ANOVA, P<0.3)**

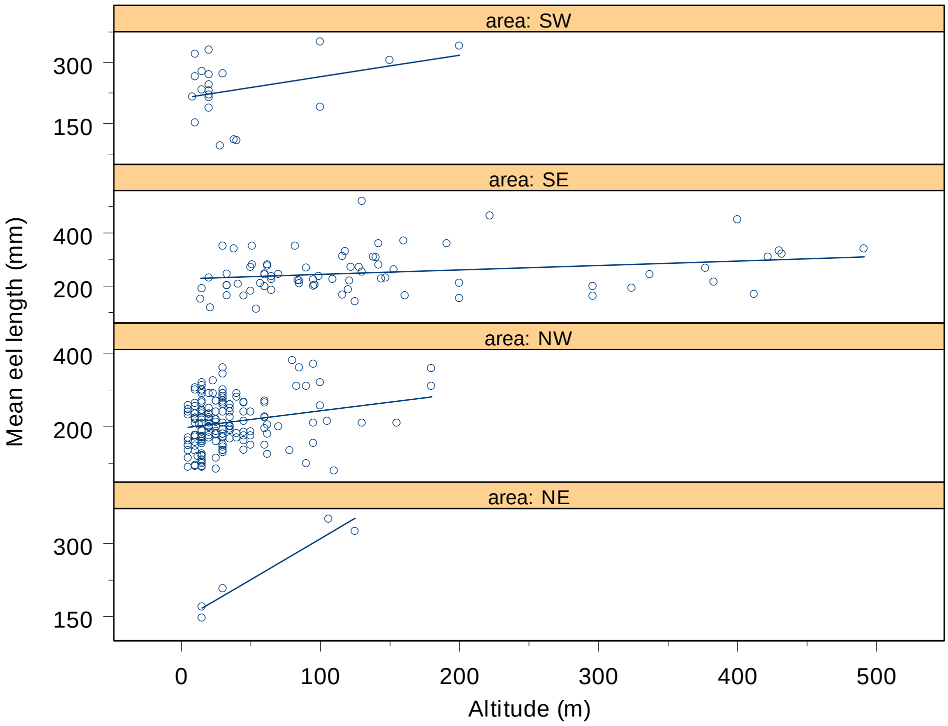


Figure 16. The relationship between average eel lengths and altitude across four regions of Scotland RBD. All individual regressions were significant P<0.05. The geographical divide is based on the Great Glen Fault. Shallow slopes are indicative of low recruitment rivers. Rivers in the south east had the most shallow slope, but there was no evidence that the slope differed between the four regions (P<0.39).

Silver Eels

Only 12 of 1143 (1.05 %) eels for which lengths were recorded were specifically reported as being "silver eels." This should be regarded as a minimum estimate of the proportion of mature or maturing eels amongst the summer freshwater stock (since other silver individuals may have had their length measured but no assessment as to their maturity status made or recorded), furthermore, the electrofishing of shallow waters may under-represent silver eels in any case. All eels reported as 'silver' were from Wester Ross (an area in the North West) where the majority of eel length data also originated. A more reliable estimate of the minimum proportion of mature or maturing eels amongst the summer freshwater stock based on information from Wester Ross alone where 12 of 832 eels were silver (=1.44%). The mean length of the silver eels was 371.3mm (s.d. =21.7). The distribution of all reported silver eel lengths is shown in Figure 17. No attempts to determine the gender of the silver eels were made.

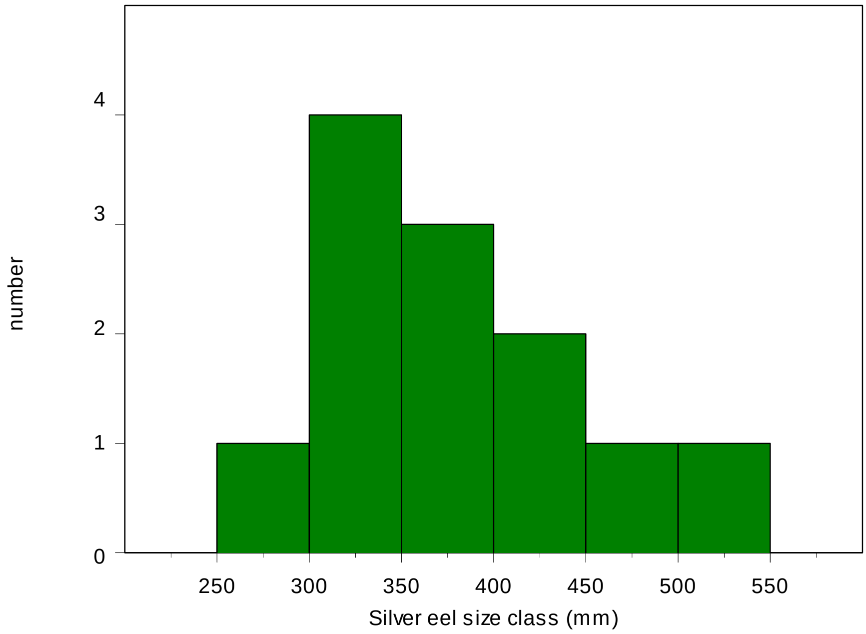


Figure 17. Size distribution of silver eels in Wester Ross, 1998-2003

Summary of abundance and trends

The analyses described above are based on all of the historical data that has been identified for Scotland RBD. The findings are based on probability tests and it should be noted that the absence of significant relationships does not constitute a proof that they do not exist. The main findings are as follows.

1) Over the period 1996-2005 there was support neither for a general decline in population density, nor an increased prevalence of sites where eels were absent. Instead eel population densities appeared stable with, at most, weak evidence for a decline post 2002.

2) There was no evidence for a contraction of overall range nor for a reduction of densities at higher altitudes.

3) Over the period 1998-2005 there was no evidence for the increase in the mean size of eels that might be expected to follow declining annual recruitment and consequent greater average age.

2.3. The Eel Fishery

Introduction

Eel fishing in Scotland has never been regulated or licensed and as a consequence there is no formally recorded information on the eel fishery, either past or present. An established eel fishery on Loch Leven was alluded to in historical documents as early as 1573 (Burns-Begg 1874, cited in Thorpe 1974), and further references can be found subsequently in the archives from the 1700s. However by 1918 a parliamentary report chaired by Lord Breadalbane sought to *establish* a Scottish eel fishery, and provided details of how to catch eels (http://www.bopcris.ac.uk/bopall/ref7947.html)

Assessment of the extent of the recent and current fishery is mostly based on word of mouth, and may not be reliable. There is likely to be reticence and even secretiveness amongst those involved in an unregulated industry, and eel fishers who elude official censuses constitute an unknown portion of the total fishery. Nevertheless, eel fishing is considered to be of little economic importance in Scotland, with the operation of various types of trap targeting different life stages being both scattered and sporadic. In the early 1970s The Highlands and Islands Development Board commissioned a report to "discover the potential of commercial eel fishing in the Highlands", which concluded that the resource was insufficient to support full time eel fishermen (Williamson 1976).

Following the adoption of *The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008* in January 2009 as part of the Scotland RBD EMP (see section 5), we do not anticipate any further (legal) fishing for glass eel in Scotland.

The effect of the Regulations is to prohibit fishing by any method for eels (*Anguilla anguilla*) in Scotland, except on application and under the authority of a licence granted by Scottish Ministers. The guidance now provided to the Scottish Government regarding application for any licences states that it is "highly unlikely" that any licences would be granted to fish commercially for eels of any size.

Elver (glass eel) fisheries

The glass eel fishery in Scotland has never been documented and no quantitative data are available. Some small scale glass eel fishing is known to have occurred in the Western Isles in the 1990's (N.Chisholm pers. comm.) and some fishing may be ongoing. A more commercial scale venture based around Lochinver has been catching glass eels at river mouths in the West Sutherland for some years and continues (May & Marshall 2008**.)** although activity is probably price-sensitive. At least one land owner is reported to have prevented fishing on a particular river (Laxford) in recent years, due to concerns regarding declining eel numbers. There is no information about the scale of this operation.

The yellow and silver eel fisheries

A review of Scottish yellow and silver eel fisheries conducted in 1989 found only 17 operational fisheries, none of which provided the sole income of those involved, and none of these fisheries is currently operating. Methods deployed included the use of Dutch fyke nets (still and flowing waters); baited eel pots (deep water) and fixed traps at river mouths for silver eels. The catches of these fisheries ranged from 0.25 to 10.76 t in 1989 (total catch in Scotland in 1989 = 23.4 t) (I.S.McLaren, Marine Scotland Science, unpublished data). This value was considered to include the major part of all eels taken in Scotland, although visiting Dutch, Danish and English eel fishermen may have taken anywhere between an estimated 10-50 t annually in the years prior to 1989. The Scottish catch of 1989 had been lower than anticipated, and over-fishing was suggested as the likely cause.

A subsequent survey in 2003 estimated that Scottish eel fisheries took about 2-3 t per annum (M.Beveridge, Marine Scotland Science, unpublished data), with yellow eels being predominant in the catch and silver eels probably contributing less than 100kg. Since 2003 there is thought to have been a further decline in eel-fishing, and in 2006 what is thought to be the last of these small-scale fisheries at Lunan Burn, Tayside, closed in 2006, with the operator reporting a decline in his catch to just 5% of its original level.

Recreational fishing
There are no quantitative data available for recreational fishing for eel in Scotland RBD. Undoubtedly some limited yellow and silver eel fishing using traps still occurs, on an itinerant basis, in some parts of Scotland RBD (Iain Mcmyn pers comm.), but this is thought to be on a very small scale. Similarly angling for eels may be practised by a few individuals, but it is not a significant part of the angling culture.

As from 2009 recreational fishing for yellow, silver or glass eels, by any method, will not be permitted in Scotland RBD without a licence (see section 5).

2.4. Escapement of silver eel

2.4.1 Estimated potential escapement of silver eel biomass in the absence of anthropogenic mortality.

We explore two general methods for generating an escapement target for Scotland RBD. The first relies on referring to data from pre-1980s at the Burrishoole, the catchment for which data is available that is regarded most similar to Scotland RBD. We expand on the Burrishoole data to include data from other catchments in Ireland. Secondly we use trap data from pre-1980 on a single small catchment within Scotland RBD itself. We then use the mean of the targets thus generated to examine the variation to assess the confidence we may place in the target itself.

2.4.1.1 Pristine escapement target based on Irish data

As there are only limited data available from Scotland itself, the potential escapement of silver eel from Scotland will first be assessed by reference to similar catchments elsewhere. The river system for which data on pre-1980 spawner escapement that is most likely to be similar to the majority of rivers in Scotland RBD is the Burrishoole in Ireland. Like much of Scotland RBD the Burrishoole lies in a maritime climate zone, drains a base-poor geology, from relatively high ground, with a large proportion of the habitat being represented by oligotrophic standing waters. However, the Burrishole catchment lies somewhat south of Scotland RBD and as a consequence is likely to be slightly warmer and more productive. Estimates, based on counts for this river from 1971-1979 given a potential spawner escapement of 0.9kg ha^{-1} (ICES 2008).

If we adopt this figure without modification for the rivers of Scotland RBD (total wetted area: 186,661 ha) we can derive a simple estimate of pristine spawner escapement, however this estimate of wetted area needs to take account for the area that is naturally inaccessible to eels. The wetted area naturally accessible to eels is estimated to be 153,729 ha, giving an estimate of pristine annual silver eel escapement for Scotland RBD of 138365 kg.

Pristine Escapement Estimate 1 (Burrishoole alone): 138,365

This method may lead to a slight underestimate in transferal to Scotland RBD, because Scotland RBD is estimated to be slightly richer in terms of the proportion of calcareous than the Burrishoole. Irish estimates of silver eel production from other, predominantly calcareous catchments (ICES 2008) where eels grow faster than at the Burrishoole, showed escapement in the region of 4.5kg ha^{-1}, and in an attempt to expand from the particular to the general productivity was described as a function of the percentage of the catchment with non-calcareous geology according to the regression:

Equation 1 Productivity (kg.ha) = -0.041* % of catchment non-calcareous + 5.18).

Accordingly we estimated the proportion of Scotland RBD that was composed of calcareous geology using techniques in GIS, data from the British Geological Survey and defining the rock-types as set out in Appendix B. The percent of the total area of Scotland RBD composed of non-calcareous formations was estimated to be 90.1% (c.f. about 96% for the Burrishoole). Applying the equation above to the Scotland RBD we generate a pristine escapement of 1.485 kg ha^{-1}, equating to 228,302 kg in total for the area of naturally accessible habitat.

Pristine Escapement Estimate 2 (5 Irish catchments and geology): 228,302kg

While this method may account for differences in eel productivity due to underlying geology both Pristine Escapement Estimates 1 and 2 are probably too high because temperatures are lower, and growing seasons generally shorter in Scotland RBD. Growth measured in the field using PIT tags to identify individual eels indicate that growth rates may be substantially lower in Scotland RBD than in Ireland. While average growth rates are reported as about 14.3mm $year^{-1}$ at the Burrishoole (Poole & Reynolds 1996) and growth rates elsewhere in Ireland range from about 17 to 35mm (ICES 2008), growth rates on one catchment in Scotland are reliably recorded as 11.6±1.2mm per $year^{-1}$ on the Girnock Burn, and provisionally (n=7) at the Baddoch Burn, as just 2.9±1.1mm $year^{-1}$ (Marine Scotland Science, unpublished data). A previous study (Williamson 1975) reported growth rates in Scotland of approximately 20mm yr^{-1}, using otoliths to age the eels. This figure likely represents maximum rather than mean growth rates for the RBD however, because the sites at which eels were sampled were selected by commercial eel fishermen, presumably for profit motives, and comprised exclusively shallow productive lakes. These data suggest that the natural production of Ireland as a whole, and even of the Burrishoole in particular, may be substantially higher than natural production in much of Scotland RBD.

The impact of growth rates on production however may not be direct, and is dependent on mortality rates. Since mortality rates of eels in Scotland RBD, and indeed elsewhere, are unknown we cannot directly assess the potential impact on natural productivity. If mortality rates positively related to growth rates (ie if mortality is lower where growth rates are lower), then there may be little difference in overall productivity. If mortality rates are independent of growth rates then substantial differences between the Burrishoole and much of Scotland are expected to exist.

The Irish model of silver eel production (ICES 2008) assumed constant mortality rates (at 14% per year) across all catchments, and modeled production as a function of growth rates and Irish average starting lengths of glass eel (70mm) and finishing lengths of silver eel (480mm).

Equation 2 $\text{Survival}=(1-0.14)^{(480-70)/G}$

Where G = growth rate (mm yr^{-1})

Then

Equation 3 Spawner production$_x$ = (Survival$_x$ /Survival$_i$)*Spawner production$_i$

Where x = target river, and i=index river

We computed spawner production for the two catchments for which growth rates were available, and modified the parameters of the exponent in Equation 2 to represent the catchment average silver eel size and growth rates.

For the Girnock, average silver eel size is 360mm, and average growth rates 11.56m. On the upland Baddoch Burn average silver eels size is 400mm and average growth rate currently estimated at 2.94 mm yr^{-1}(Marine Scotland unpublished data). Because eels in these two catchments mature on average at a smaller size than those in Ireland, the index production needs to be modified to avoid an underestimate of production. We assumed the mass of a 480mm eel to be 172g, 400mm eel to be 102g, and a 367mm eel to be 78g. These result in a correction factor of x78/172 to be applied at the Girnock, and x102/172 to be applied at the Baddoch. Applying this correction factor together with Equations 2 and 3 above, a figure of predicted pristine escapement of **0.58kg/ha** is generated for the Girnock, which is similar to the current measured escapement from the catchment (see below). For the Baddoch however the pristine escapement target was calculated as **0.000002 kg/ha**, which is below the current measured escapement by over 6 orders of magnitude (see below). We conclude that the assumption of constant mortality rates across catchments used in Ireland cannot be reliably transferred to Scotland RBD, and particularly not to upland catchments with very slow growth rates. Accordingly we eschew both the predictions for the Girnock and the Baddoch based on constant mortality assumptions, and reject the use of the second regression equation developed for Ireland (ICES 2008) which uses the output of the survival/growth rate model (ie equations 2 and 3) to generate predictions of productivity based on catchment geology.

With regard to the Irish data we are therefore left with two estimates which may both overestimate pristine productivity in Scotland due to growth rates in the index rivers being up to an order of magnitude faster than in the target rivers. At present we are aware if no way to address this, but it is hoped that the development of Scenario-Based Model for Eel Production being developed by the Environment Agency, or other modeling developments elsewhere, will allow us to address this issue in future EMPs.

2.4.1.2. Pristine escapement based on historical data.

A second, unrelated method for generating a pristine escapement target is available, based on data from a single small catchment of 2970ha, the Girnock Burn, a tributary of the River Dee. Some characteristics of this burn are shown in Table 3. Historical data on silver eel escapement at this site extend back to 1966, when a trap designed to catch salmon smolts was erected. The trap samples the entire flow of the river, using screens with 6mm gaps between bars. In most conditions these can be expected to catch all migrating silver eels. However, silver eel migration at these sites is associated with late summer and early autumn spates, and during the latter part of the migration period traps may overflow when high numbers of leaves block the screens, potentially allowing silver eels to bypass the trap. It is likely therefore that some downstream migrating eels are missed by the trap in most years, but the extent and timing of trap spillage varies between years and potentially therefore part of the apparent variation between years in silver eel numbers is an artifact of environmental conditions. Accordingly years with *maximum* escapement years may be a more reliable indicator of true escapement than using mean escapement across years. At present we cannot quantify the extent to which spillage occurs.

There are complete year's data from 1967-1981, then a hiatus until data collection resumed in 2002, although complete data are available only for 2003, 2007 and 2008.

These data allow us to compare pristine (pre 1980) escapement with present day escapement, however, there is some evidence that the trap itself has curtailed eel movements into the burn (Chadwick *et al* 2007), and in the data set of barriers used in this EMP the trap at the Girnock appears as a Manmade Impassable Barrier. That young eels nevertheless manage to recruit to the burn is evidenced from size-distribution data from electrofishings at the same 6 standard sites in the two periods (Fig 18), which do not differ significantly from each other (Past n=826, mean 221mm; Present n=711, mean=220mm, Wilcoxon rank test, Z = 0.7659, p-value = 0.4437). Individual years from 1968 onwards show some vartiation in size frequency of eels caught by electrofishing (Fig 19) though there is no evidence that the construction of the Girnock trap (in summer 1966) had a dramatic effect on the size distribution, although there is no data for 1966 and 1967. Nor is there evidence of reduced contribution of small eels to the burn following the European wide recruitment collapse around 1980. Over this period, however, despite no evident changes to size distributions, the estimated density of eels has fallen from 16 to 3 eels $100m^{-1}$ (Chadwick *et al* 2007).

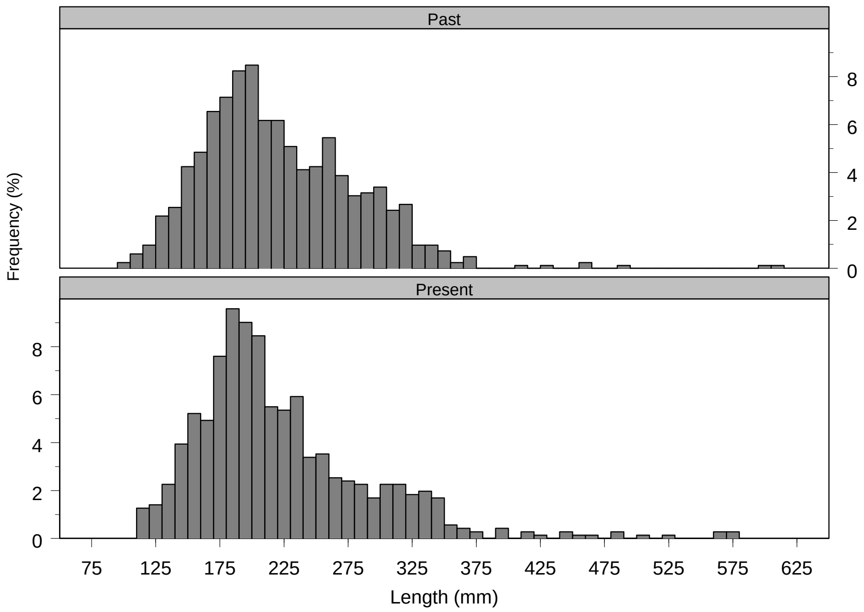


Figure 18. Size distribution of eels caught by electrofishing above the Girnock Trap in two periods: past (1968-1981) and present (2002-2008). There is no significant difference in the two distributions.

The mean length at which eels ascend into the burn has been recently measured at around 160mm (range 95-215), while mean spawner escapement size was 342mm in the 60s and 70s, and has risen to 367mm in later years. Growth rates in this catchment are currently estimated at 11.6mm/yr. Even if recruitment to the burn was curtailed by the building of the trap, this rate of growth should mean that the number of mature eels leaving the catchment would remain unaffected – except perhaps from reduced densities of smaller eels in the burn – for about 15 years. The second period of data, beginning in 2003, represents a time 37 years after the trap was first installed. By this stage only very large eels, of which there are very few in the catchment, could have entered the burn prior to the suggested curtailment of recruitment caused by the trap in 1966. Recruitment to the burn is expected to have fallen again post 1979, as glass eel numbers fell throughout Europe. This second potential decline in recruitment to the burn, now 20 years ago, would be expected to have started having an impact on silver eel output during the more recent period of data.

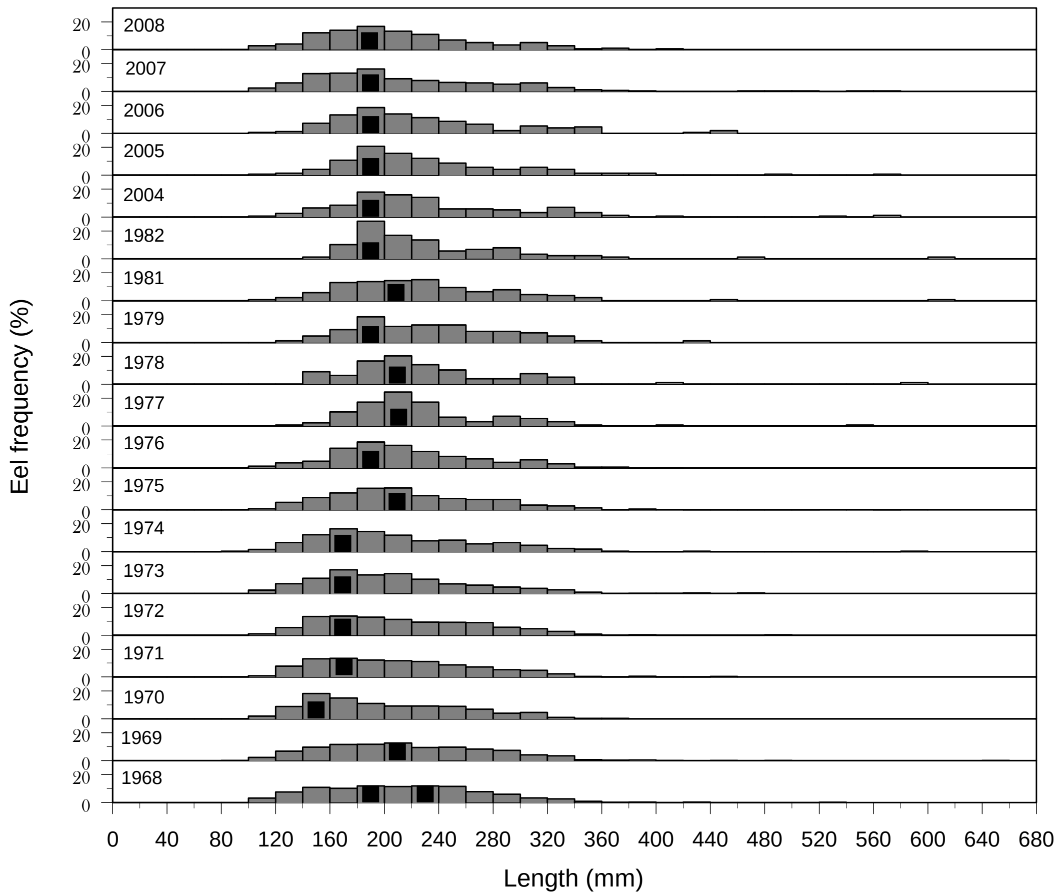


Figure 19. Size distribution of eels caught by electrofishing above the Girnock trap for individual years between 1968 and 2008. Black bars indicate the median. Distributions show no evidence for recruitment declines associated with the construction of the Girnock trap in 1966, nor the Europe wide recruitment collapse of 1979.

During the period 1967-1981 the mean (±s.e.) annual spawner escapement was 1.16±0.12 kg ha^{-1}. Maximum annual spawner escapement, in 1975, was 2.23 $kgha^{-1}$. Multiplying these figures by the total available habitat of Scotland RBD naturally accessible to eels (153,739ha) yields two more possible targets.

Pristine escapement estimate 3a (mean historical Girnock) = 184,487 kg

Pristine escapement estimate 3b (maximum historical Girnock) =342,838 kg

Although estimates 1 and 2 are not independent, they contain different information, and so, together with estimate 3a (or 3b) can be combined to yield a mean estimate of spawner escapement. Estimates 3a and 3b are not independent of each other, and so only one can contribute to a mean estimate. Although using 3b instead of 3a would lead to a higher estimate of the target, it would also necessarily entail using maximum rather than mean estimates of actual escapement, and so make the target easier to achieve. Accordingly we use the mean of estimates 1, 2, and 3a to generate our best estimate of the pristine spawner escapement at 1.19±017kg ha^{-1}, equating to a total output from the naturally accessible habitat of Scotland RBD of 183,718±s.e.25,965 kg (Table 3) and making a minimum acceptable output for the RBD, defined as 40% of the pristine escapement, of 73,487±10,386kg (Table 3). The lower and upper 95% confidence intervals of this mean are 28,799 and 118,175 kg respectively.

Pristine escapement estimate	Description	Source	Test against	Spawner escapement kg ha^{-1}	Total Spawner Escapement Biomass±s.e. (kg)	40% escapement Target±s.e. (kg)
1	Burrishoole	ICES 2008	Scotland RBD mean	0.90	138,365	55,346
2	5 Irish catchments + geology	ICES 2008	Scotland RBD mean	1.485	228,302	91,321
3a	Girnock 1967-1981, mean	Marine Scotland *unpubl.*	Girnock 2003-2008 mean	1.157	184,487	73,795
3b	Girnock 1967-1981, max	Marine Scotland *unpubl.*	Girnock 2003-2008 max	2.227	342,838	137,135
Rejected	Burrishoole + survival and growth	ICES 2008 and Marine Scotland *unpubl.*	Baddoch Burn present	0.000002		
Rejected	Burrishoole + survival and growth		Girnock Burn present	0.580		
Best estimate ((1+2+3a)/3)	Mean of estimates 1,2 and 3		Scotland RBD mean	1.180±0.17	183,718 ±25,965	73,487 ±10,386

Table 3. Summary of pristine escapement estimates for Scotland RBD.

2.4.2. Estimates of current silver eel escapement

Three data sets were available for use in assessing the current silver eel escapement biomass of Scotland RBD, all three originating from traps built on small catchments originally designed to catch downstream migrating salmonids. These are on the Girnock Burm the Baddoch Burn (both upland tributaries of the River Dee) and the River Shieldaig, a low lying catchment on the west coast of Scotland. All three catchments have unexploited eel stocks, in common with the majority, of Scotland RBD.

2.4.2.1 Description of the data.

The Girnock Burn. Data for migrating eels go back as far as 1966, when the trap was built, and were recorded annually until 1981. Thereafter some sporadic records were take, with complete data available for 2003, 2007 and 2008. There is a possibility that recruitment to the burn has been affected by the construction of the trap (Chadwick *et al* 2007) which acts as a complete barrier to upstream movement in salmonids. Nevertheless young eels are still caught above the trap in reasonable numbers (Fig 20). In 2008 an elver pass was constructed to allow free access.

The Baddoch Burn. The trap on this catchment was built in 1989. Partial collection of data on migrating eels began in 2002, with complete data available only from 2006 to 2008. The trap is not thought to impede upstream access for eels significantly.

The Shieldaig River. The trap on the Shieldaig was built in 1999, and data on migrating eels was recorded in full for all subsequent years excluding 2000, 2001, 2005 and 2005. The trap is not thought to impede elver access to the catchment.

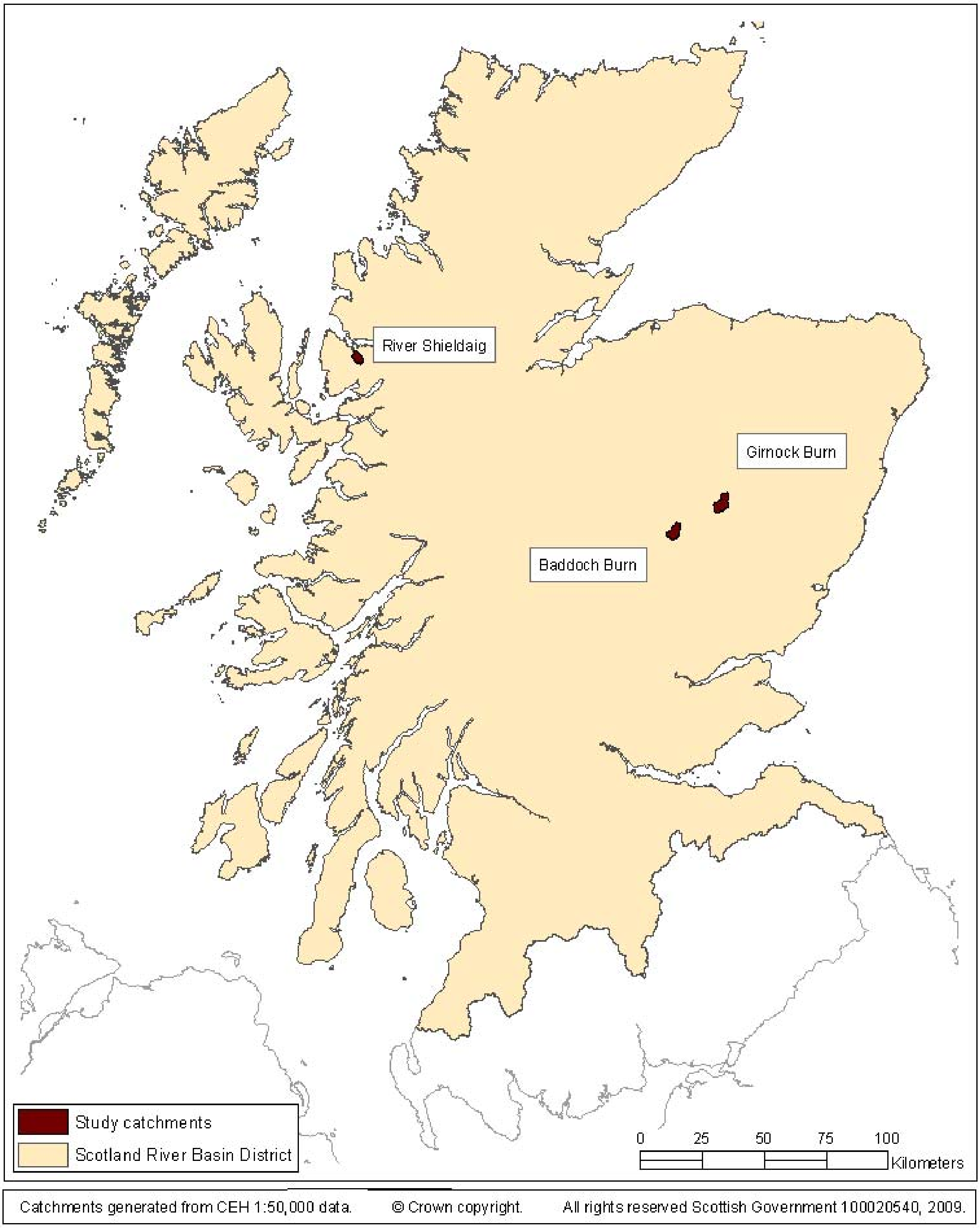
Further details of all three catchments are shown in Table 4, and their location shown in Map 5.

	Shieldaig	Girnock	Baddoch
Catchment area	1392 ha	2970 ha	2309 ha
Wetted area	18.6 ha*	9.4 ha	19.4 ha
Running water	3.7 ha*	9.4 ha	10.0 ha
Standing water	14.9 ha*	0 ha	9.4 ha
Altitude of trap	10m	240m	415m
Maximum altitude	110m*	580m	905m
Catchment solid geology calcareous	0 %	5 %	60 %

* Figures marked with an asterisk account for Natural Impassable barriers. Without accounting for the impact of these barriers the figures are Wetted area 25.9ha, running water 5.6ha, standing water, 20.3ha, maximum altitude 520m.

Table 4. Characteristics of the three catchments where silver eel escapement has been recorded in Scotland RBD.

All three traps were designed to sample the entire flow of the river, using screens with 6mm wide spaces between the bars. In most conditions these can all be expected to catch all migrating silver eels. However, silver eel migrations at these sites are associated with late summer and early autumn spates, and during the latter part of the migration period traps may overflow when high numbers of leaves block the screens, potentially allowing silver eels to bypass the trap. Accordingly maximum annual escapement may represent a better estimate of true escapement that the mean of annual values (see section 2.4.1.2, paragraph 1).



Map 5. Location of the three catchments used to derived estimates of current silver eel escapement from Scotland RBD.

2.4.2.2. Size distribution of downstream migrants

All three trap sites caught eels with a similar modal length (around 340mm), but varying numbers and sizes of larger eels resulted in differing mean length of silver eels between the three sites: smallest at the Girnock (344.2±0.67mm mean±s.e., n=3024), and largest at the Baddoch (399.7±10.0mm, n=247) with the Shieldaig eel intermediate at 366.7±1.85, n=871) (Figure 20).

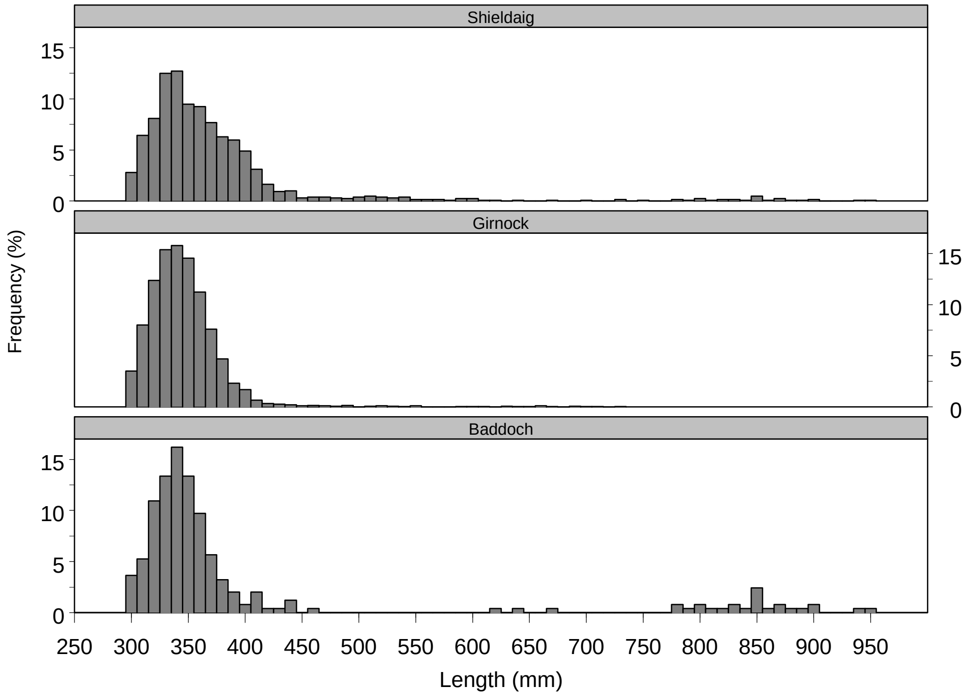


Figure 20. Size distribution of silver and silvering eels at three trap sites in Scotland RBD.

The mean length of silver eels at the Girnock was significantly shorter during the early period of measurement: mean from 1966-1981 was 341.9±0.72 mm and from 2002-2009 was 366.7±1.85). This can be seen to have resulted not solely from a small increase in the proportion of large female eels in the catch, but also in an increase in the modal size of the smaller silver eels. This may be a result of reduced density dependence consequent on reduced population density in the burn (Chadwick *et al* 2007), possibly effecting growth rates and/or mortality. At the same time the proportion (and number) of smaller migratory eels (<260mm) has declined markedly (Figure 21). It is not clear whether this reduction in smaller eels at the Girnock trap is a consequence of the reduced upstream population density, or whether trap efficiency for smaller eels has declined as the trap has aged, and as the number of person hours put into servicing it has declined.

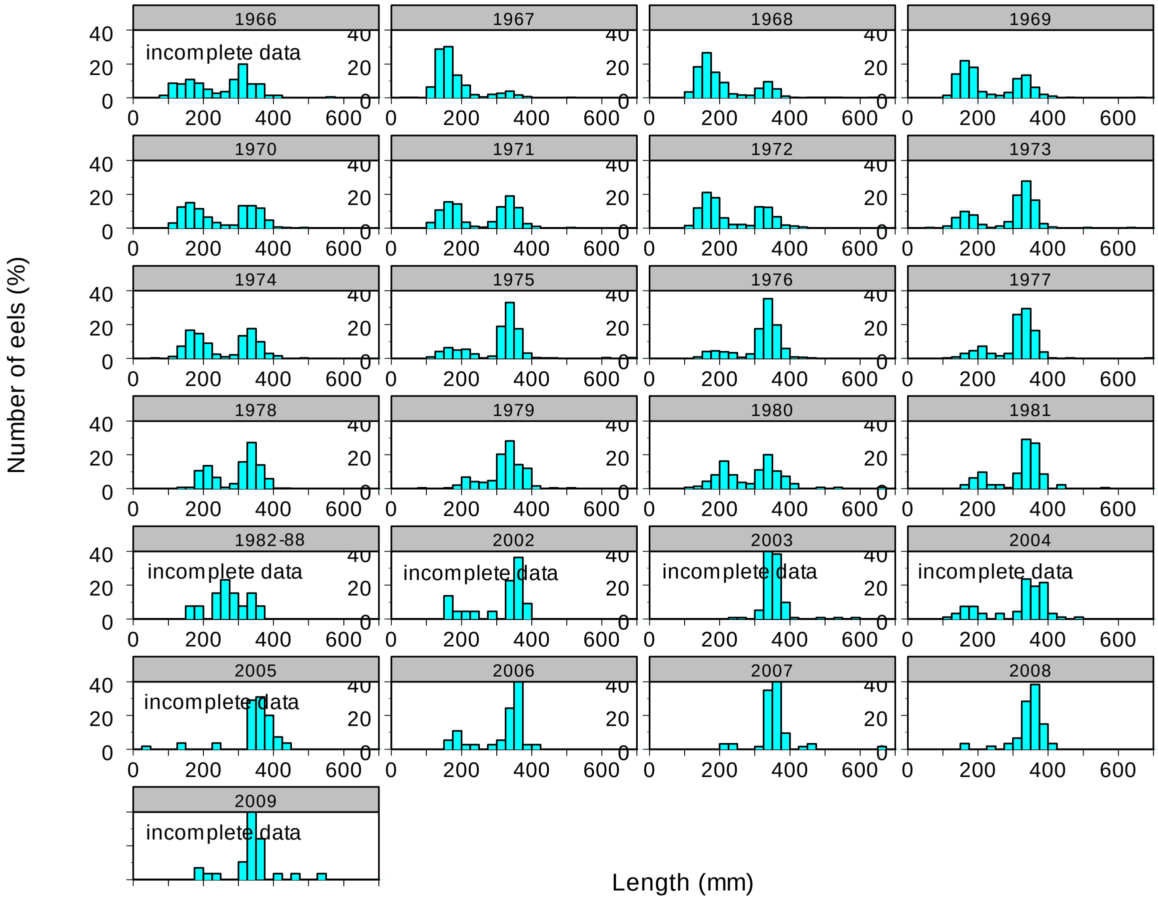


Figure 21. **Size distribution of eels caught in the downstream trap at the Girnock from 1966 to 2009. The distribution shows bimodality, but the proportion of the smaller eels has decreased markedly through the period sampled. Amongst the larger eels the modal length has increased.**

2.4.2.3. Standing stock in the three catchments

The length distribution of the standing stock of eels in the three catchments, sampled by electrofishing, is indicated in Figure 22. Substantial differences exist between sites. At the Girnock there is unimodal distribution with a peak at around 180mm, whilst at the Baddoch and Shieldaig it is bimodal, with peaks at around 200mm and 300mm. There are relatively few small eels at the Baddoch, as expected from its greater distance from, and height above, the sea (Ibbotson *et al* 2002).

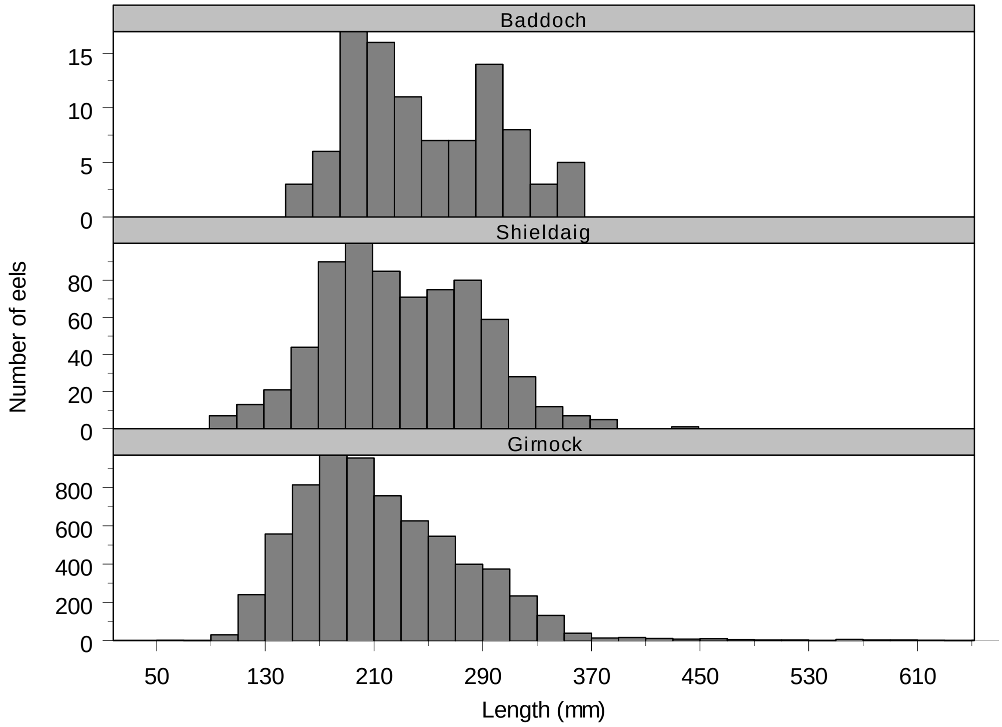


Figure 22. Length distribution of the standing stock of eels in the three catchments, sampled by 3-pass electrofishing. Baddoch 2005-2008, Shieldaig 1999-2008, Girnock 1968-2008.

2.4.2.4. Silver eel escapement from the three catchments.

Eels were identified as either silver or silvering on the basis of colour definition, lateral line definition and eye size. Different personnel made these assessments over the years and we cannot be certain how consistently the criteria were applied, both between and within sites. Eels were anaesthetised, and measured to the nearest mm using measuring boards, and, usually, weighed using electronic balances to the nearest 0.1 g. Where mass was not recorded this was estimated using regressions of log weight on log length from measured eels at the same site (Table 5). At the Girnock two regressions were performed one for eels < 415mm and one for eels > 415mm, since a single regression performed poorly for larger eels, at the other sites a single regression for all silver eels was adequate. Using the measured and predicted mass of eels we calculated the total mass of silver or silvering eels leaving each catchment in each year for which complete data were available.

	intercept	slope	R^2
Shieldaig, all eels	-5.6996	2.9705	0.9294
Girnock, eels < 415mm	-4.3509	2.4339	0.6909
Girnock >415mm	-6.2227	3.1546	0.9679
Baddoch, all eels	-6.0348	3.0909	0.9812

Table 5. Regressions predicting log weight (g) from log length (mm) of silver Eels

Catchment	Mean±s.e. annual spawner escapement (kg ha^{-1})	Maximum annual spawner escapement (kg ha^{-1})
Baddoch	0.417 ±0.08	0.575
Girnock	0.663 ±0.30	1.055
Shieldaig	0.785 ±0.20	1.570

Table 6. Recent measures of silver eel biomass escapement from three trap sites in Scotland RBD, post-2000.

Using techniques in GIS (see section 2.5.6 for details) we calculated the wetted area for each of the three catchments, adjusting the wetted area on the Shieldaig to account for natural barriers to eel migrations, assessed by electrofishing (Walker & Northcott 1995)). We used these to generate estimates of mean annual spawner escapement in kg ha^{-1}, and also maximum annual escapement estimates, since these may be better estimates of true productivity than mean values. Productivity was in line with altitudinal range across the three catchments, with the low lying Shieldaig (10-110m) having the highest mean (0.785 kg ha^{-1}) and maximum (1.570 kg ha^{-1}) values, while the upland Baddoch (415-905m) had the lowest mean (0.417 kg ha^{-1}) amd maximum (0.575 kg ha^{-1}) values, while the moderate altitude Girnock (240-580m) had intermediate values (Table 6).

Given these differences in productivity, which likely result from decreasing eel density with altitude/distance from the sea (Ibbotson *et al* 2002) together with temperature-mediated differences in growth rates, we sought to exploit the different altitudes of the three index catchments in expanding from them to estimate production of Scotland RBD as a whole. Again we used GIS techniques to estimate the total wetted area of Scotland RBD divided into three altitude bands: 0-239m, 240-415m and > 415m, so that each band was represented by one of the three catchments. We then used these to calculate total output of silver eel biomass in kg from Scotland RBD (Tables 7 and 8).

		Below natural impassable barriers		Below hydro-scheme barriers		Below all manmade impassable barriers	
Altitude (m)	Mean Spawner production (kgha^{-1})	Wetted area (ha)	Spawner production (kg)	Wetted area (ha)	Spawner production (kg)	Wetted area (ha)	Spawner production (kg)
0-240	0.785	129,229	101,445	124,544	97,767	97,684	76,682
240-415	0.663	19,578	12,980	18,868	12,510	10,853	7,196
> 415	0.417	4,932	2,057	4,753	1,982	2,532	1056
Total		153,739	116,481	148,166	112,259	111,124	84,933

Table 7. Estimated total output of silver eels from Scotland RBD, based on mean recorded escapement at three catchments post 2000, and on GIS-based estimates of the amount of habitat in 3 altitude bands.

2.4.2.5. Current spawner escapement in relation to target escapement.

In deriving our estimate of current spawner escapement, we elected to use mean annual escapement rather than maximum annual escapement, even though this must certainly underestimate true escapement (see 2.4.1.2, paragraph 1). Our best estimate of current spawner escapement from Scotland RBD, assuming that no eels ascend above barriers defined as Manmade Impassable is 84,933kg (Table 7). The estimate is lower than the predicted pristine escapement for Scotland RBD of 183,718 ±25,695 kg, and meets the required 40% of this estimate 73,487±10,386, representing in fact 46.2% of the pristine escapement estimate. We do not claim this figure is accurate, nor have we any means of attaching error estimates to it. While errors are involved in at many stages and in many assumptions used to generate both pristine and current escapement estimates (listed below), we attempted to err on the side of caution where possible. Had we used maximum annual escapement as our estimate of current escapement we would have come to the conclusion that current escapement was 166,269 kg (Table 8), or 90.5%, of pristine escapement, a figure exceeding the 95% confidence interval of our best estimate of pristine escapement biomass. Also shown in Tables 7 and 8 is the estimated impact of Hydro-schemes alone on production, based on the assumption than no production occurs above hydro-scheme turbines. Using data derived from mean annual escapement estimates escapement below hydro-scheme barriers is 112,259kg or 61.1% of estimated pristine production. This amounts to lost production in the region of 4222 kg, or 3.6%, from that predicted in the absence of any manmade barriers.

		Below natural impassable barriers		Below hydro-scheme barriers		Below all manmade impassable barriers	
Altitude (m)	Max Spawner production (kgha^{-1})	Wetted area (ha)	Spawner production (kg)	Wetted area (ha)	Spawner production (kg)	Wetted area (ha)	Spawner production (kg)
0-240	1.570	129,229	202,890	124,544	195,534	97,684	153,363
240-415	1.055	19,578	20,655	18,868	19,906	10,853	11,450
> 415	0.575	4,932	2,836	4,753	2,733	2,532	1456
Total		153,739	226,381	148,166	218,173	111,124	166,269

Table 8. Estimated total output of silver eels from Scotland RBD, based on the maximum spawner escapement measured at three catchments post-2000.

We emphasize that at several points in the process of setting our target escapement for Scotland RBD, and in its assessment, we have erred on the side of caution, and made it less likely that the target would be achieved for Scotland RBD.

1) We used mean annual trap catches to measure spawner escapement when there is a high probability that these underestimate true escapement, and that the degree of underestimation may reflect river flow conditions during late summer/early autumn. For this reason maximum annual escapement over a period of years may give a more accurate representation of true mean escapement. We avoided using maximum values to ensure we were not overestimating true escapement.

2) In the historical vs current production comparison on the Girnock Burn assessing the potential effect of a natural decline in recruitment, also includes the presence of "manmade impassable" barrier (the building of the Girnock trap.

3) Escapement estimate 2 incorporates a regression line the estimates the impact of calcareous geology on production. This was performed on 4 mainly calacareous catchment and one mainly non calcareous catchment. Inevitably the fit for the non-

calcareous catchment (the Burrishoole) is rather poor, and this happens to have led to a random overestimate of production at the non-calcareous site, rather than a random under-estimate of production. Since Scotland RBD is also principally non-calcareous this random error leads to setting a target more likely to be too high than too low.

4) Escapement estimates based on measured growth rates in Scotland were rejected because they generated low estimates of pristine production. Accordingly, no account has been taken of the lower growth rates in Scotland RBD in comparison to Ireland.

5) Our ultimate test of current production against target production, makes the assumption that manmade barriers defined as Impassable to salmonids are also impassable to eels, and that zero spawner production occurs above them. This is despite very clear evidence from the Girnock Burn that a barrier specifically designed to exclude fish has at most only a limited impact, and possibly no impact at all, on eel recruitment upstream.

6) We assume that zero production occurs above hydro-schemes, even though in some cases eels can ascend above turbines. We effectively assume that all eels attempting to descend through the turbines die. In fact a more typical mortality rate might be in the region of 20-30% mortality. Accordingly some spawner escapement from zones above hydro-scheme barriers is likely to occur.

7) Where barriers are assumed to prevent eels ascending further, we assume that there is no increase in production downstream consequent on higher population density. Effectively we are making the assumption that freshwater habitat in Scotland RBD would be perfectly saturated by eels if there were no manmade barriers, such that any increase in population density would lead to zero increase in production.

There are a few assumptions which might lead to our estimate of current escapement to be insufficiently cautious:

1) Given the ease with which eels ascend very substantial “impassable” barriers (Girnock Burn, see 5) above) we have assumed that “passable” manmade barriers do not affect eel production.

2) With reference to point 6) above, while we incorrectly assume no production occurs above hydro-scheme dams, we also effectively assume that there is no impact on production downstream where eels do manage to ascend above turbines.

3) Only one of our three index traps measures silver eels immediately as they escape to the sea, while the other two are at some distance inland (ca 65 and 85 km). We have assumed that mortality of eels in their continued journey to the sea is trivial, but we have no supporting evidence for this.

Our most important assumption, that the three silver eel traps are 100% effective, is almost certainly violated. We can assess the potential scale of this violation by testing historical silver eel escapement records directly with their modern counterparts on the

Girnock Burn,, in effect controlling for trap efficiency. The mean value of escapement in recent years was 0.663 kg ha^{-1}, representing 57% of the 1966-1981 mean. This is 11% higher than the estimate derived when treating mean measured escapement as true escapement, and so we might tentatively conclude that on average the trap catches in the region of 80% of migrating silver eels. This suggests that using maximum annual production values would substantially overestimate true mean production, because maximum values were approximately double mean values. Furthermore production estimates per hectare derived from maximum annual escapement led to current production being estimated to be more than 10% above the Pristine Production Estimate derived in section 2.4.1, again arguing against the use of the maximum annual production over a period of years rather than the mean annual production of those years.

The person-days available to service the trap is currently substantially lower (post 2002) than it was from 1966-1981, and accordingly we expect that trap spillage, with potential loss of silver eels, is more frequent than formerly. Additionally the introduction of the trap itself, defined as a Manmade Impasssable barrier, may have led to a reduction of recruitment in the burn, which would be expected to have limited affect on silver eel output in the early period due to slow growth rates in the burn. Inherently these figures therefore take account of the impact of manmade reduction of habitat availability. Both these effects, though of unknown size, will lead to a current escapement estimate that tends to over-estimate the decline of eel productivity if applied to the RBD generally.

On balance we believe our pristine escapement estimate is likely to be an *over*estimate of pristine production in Scotland RBD, while our current escapement estimate is very likely to be an *under*estimate true escapement. Accordingly, in the absence of further information, and based on more than one line of evidence we conclude that Scotland RBD is currently meeting its target spawner escapement for eels, by achieving at least 46% of estimated pristine production. It is not realistic to attempt to derive a numerical estimate of the confidence of this conclusion.

Refinement of estimates in the future.

1) Assessment of trap efficiency at Girnock, Baddoch and Shieldaig. It may be possible to carry out mark-recapture experiments, by catching silver eels upstream of the traps in summer, making the assumption that all eels silver in summer will descend through the trap during the following months, and assessing trap efficiency by the proportion of marked silver eels that are recaught at the trap.

2) It is hoped that standing stocks of eels estimated by electrofishing from a selection of catchments can be related to spawner escapement using the Scenario-based Model for Eel Populations (SMEP) being developed by the Environment Agency (see section 4.1). The validity of these predictions can be assessed by applying SMEP to the three catchments with known silver eel escapement. Other modeling developments will be reviewed regularly and applied if appropriate.

2.5 Eel mortality and condition of available habitat

2.5.1. Water Quality

Water quality is generally considered good in Scotland RBD. According to SEPA, "overall, the district has fewer environmental problems than most others in the UK. However, there are still significant environmental problems in parts of the district, in particular around the larger population centres of Glasgow and Edinburgh. Although many large rivers and estuaries, such as the Clyde in the west and the Forth in the east, have seen marked improvements over the last 20 years, water quality problems remain. Land use in the north eastern part of the district is largely agricultural which can give rise to diffuse pollution problems." Data on water quality for the whole of Scotland has been collected since 1976 and refined since 1996 by SEPA. Data for the period shows that poor water quality (grades C and D) accounts for only around 2-2.5% of channel lengths (based on a data set comprising 50,252 km of river channel in the whole of Scotland) and that the length of channels in the two lowest categories has been declining (Table 9).

Year	% total channel length with water quality in class				
	A1 Excellent	A2 Good	B Fair	C Poor	D Seriously Polluted
1996	75.1	16.3	6.0	2.3	0.27
1997	73.8	17.0	6.6	2.3	0.28
1998	72.2	17.9	7.4	2.3	0.22
1999	72.1	18.3	7.0	2.3	0.19
2000	72.6	18.7	6.8	1.7	0.17
Percentage change (1996-2000)	-2.5	2.4	0.8	-0.6	-0.11

Table 9. Water quality classes by % channel length in Scotland 1996-2000, based on a channel network of 50,254 km

After 2000 SEPA switched to a digitally based monitoring network, which includes around half the length of channels. This system removes a higher proportion of the smallest upland streams from the network, which has the effect of reducing the proportion of the highest quality A1 grade in the data set. However, even using this system only around 3% of channel lengths is of poor quality, and only 0.2% is regarded as seriously polluted (Table 10). On this basis water quality is thought unlikely to be a major factor impacting adversely on eel populations in Scotland RBD.

Class	Description	Length (km)	% total length
A1	Excellent	6815	26.8
A2	Good	9540	37.5
B	Fair	2374	9.3
C	Poor	751	3.0
D	Seriously Polluted	53	0.2
U	Unclassified	5903	23.2

Table 10. SEPA river water quality classification by channel length (data from 2003 for the whole of Scotland, based on the Digital River Network of 25,346 km)

2.5.2. Contaminants in eels

For several years SEPA have been using eels as bio-monitors of water pollutants such as organophosphates, brominated flaminants, PCBs and organo-chlorines (such as Lindane and DDT). We have not yet been able to access these data, however the eels analysed were selected from areas with dubious water quality, so would not in any case provide a data set for establishing the extent of contaminants or potential mortalities therefrom, in the population of Scotland RBD. From 2009 onwards SEPA will undertake to assess contaminant loadings in eels collected from a range of sites in Scotland (see Map 7). It is anticipated that this will involve up to 120 eels per year.

In the absence of data on contaminants, we assume that the impact of contaminants on eels in Scotland RBD is small, simply because the proportion of freshwater habitats that are regarded as polluted by SEPA is small (see Table 4).

2.5.3. Effect of parasites

Recently introduced eel parasites have been suggested to be contributory to the decline of the European eel. In particular the nematode *Anguillicoloides crassus*, a parasite native to the Japanese eel (*Anguilla japonica*), that infects the swimbladder, was probably introduced to Europe in the 1980's via international trade in eels (Peters & Hartmann 1986), and is thought to be spread through the movement of water (Kennedy & Fitch 1990). It thus qualifies as an anthropogenic influence on eels. There is evidence that although the parasite does not generally kill its host directly, it may compromise performance (Gollock *et al* 2005) and in particular the ability of silver eels to complete the migration to the Sargasso Sea (Kirk 2003).

Although the parasite appeared to have become widespread in England and Wales rather rapidly after its first appearance in 1987 (Ashworth 1995), there is to date only a single reported instance of *Anguillicoloides crassus* in Scottish RBD (Lyndon & Pieters 2005), for a fish farm near Bridge of Earn, on the Tay system. Although the single detected case appears to have been an isolated incident, the absence of targeted effort on the identification of *A. crassus* in the Scottish RBD may have led to under-recording. However, the parasite is relatively easy to detect (Matt Gollock pers. comm.), and is currently being sought in eel samples collected in the catchments of central Scotland, and there is a recent report of infected eel from the Forth catchment (Willie Yeomans, pers. comm). However, the likelihood is that *A. crassus* is not sufficiently widespread as yet in Scotland, due to low levels of stock transfer, to have had significant impacts on eel populations.

SEPA will be sampling up to 120 eels over each of the next 6 years, principally to assess contaminant loads, from about 200 sites across Scotland RBD (see Map 7). The swimbladders of these fish will also be examined by MSS to determine the presence or absence of *A. crassus*.

2.5.4. Pathogens

European eels are subject to a range of viral infections. HVA (*Herpesvirus anguillae*), appears to be wide spread in farmed eels both in Europe and in the Far East. It was not reported in wild eels until 2004, but may be wide-spread. Its effects are highly variable, but generally sub-lethal. EVEX (Eel Virus European X) is a rhabdovirus that affects blood-forming tissues, and outbreaks during times of stress. EV2 or Cauliflower disease is a virus that produces skin tumours, generally around the jaws. These may grow in appearance similar to a cauliflower, or blackberry, and may become as big as the eel's head. Large growths may appear to block the mouth entirely, and in such cases the eel is generally found to be emaciated and with an empty stomach.

There are no reports of these, or other eel diseases in Scotland RBD, except for a single individual thought to be suffering from EV2 (in 2007 on the river Spey). The likely contribution of pathogens to eel mortality in Scotland is therefore assumed to be minimal, but no formal estimates can be made.

2.5.5. Predators

Predation was considered in the WGEEL report in 2007 (EIFAC/ICES 2007), where cormorants (*Phalacrocorax carbo*), herons (*Ardea cinerea*) sawbill ducks (*Mergus merganser* and *Mergus serrator*) otters (*Lutra lutra)* and mink (*Mustela lutreola*) were identified as principal eel predators, with cormorants thought to represent the most significant impact. In Scotland the breeding population of cormorants is thought to be around 3500 pairs, with a further 4000 non-breeders. The winter population is in the region of 9,500 to 11,000 birds (Forrester & Andrews 2007). In Scotland RBD itself these numbers can be expected to be in the region of 10-20% lower. WGEEL (ICES 2008) estimated that 460,000 cormorants in 19 European countries consumed around 5000 tonnes of eels (with the assumption that eels comprised 6% by weight of the diet of cormorants). Data from Scotland in the mid 1990s (Marquiss *et al* 1998) suggested a similar contribution of the eel to cormorant diets (less than a third of stomachs contained eels, and where eels were found they contributed around 23% of food by weight, suggesting eel contributed <7%). We therefore estimate the consumption of eels by cormorants in Scotland RBD to be in the region of 10 tonnes per year. This figure should be regarded with great caution as it contains many assumptions and uncertainties. We have no information about the relative contributions of yellow or silver eels to this estimated total.

There are no quantitative data which can be applied to the other predators of the eel mentioned above.

The bird species mentioned above receive protection under the Wildlife and Countryside Act 1981 (as amended). This transposes the requirements of the EC Birds Directive, including the derogation which allows for the lethal control of birds in certain circumstances (including the prevention of serious damage to fisheries) through licensing procedures.

2.5.6 River connectivity

No specific data are available to assess directly the potential impact of man-made obstructions to eel migration in Scotland RBD. Instead we exploited data from various Fisheries Trusts that had been collected in order to assess barriers to salmonid migration. This is the best available proxy measure for assessing barriers to eel migration. We assess the potential loss of eel habitat due to man-made barriers using these data. In this analysis we could not account for distance of the habitat from the sea, although it is well known that eel densities naturally decline with distance from the sea (Ibbotson *et al* 2002, Smogor *et al* 1995, though see Laffaille *et al* 2003). It should be noted that since distance from the sea could not be accounted for in this analysis, and since barriers to migration must necessarily impact more widely on the upper rather than lower parts of catchments, the analysis has a bias towards over-estimating the true impact of man-made barriers on eel populations.

Based on the area for which barrier information was collected we used procedures in GIS to estimate the extent (in terms of wetted channel width and area of standing freshwater bodies) of the potential impact of the various classifications of barriers. Because the grid references for the locations of barriers were not always perfectly in accord with the digital river network, we initially used a digital ‘snapping’ or ‘cracking’ procedure in GIS to move the sites to the nearest river channel, using the full detail digital network (based on O/S MasterMaps, Scales 1:10,000 and 1:1,250). We also used the full detail available to estimate the total potential extent of eel habitat. Although the level of detail represented by the barrier data was unlikely to extend to full coverage of some of the smaller channels included in the estimate of potential eel habitat (leading potentially to an underestimate of the impact of barriers), it was thought that this potentially underestimate would be more than offset by the natural decline in eel densities with distance from the sea. The effect of various barrier types on available channel areas is shown in Table 11.

Below a certain channel width (defined as normal winter flow width) the digital network represents channels as a single dimensional line, which thus provides no data on the width of river channels. On 1:10,000 scale maps this occurs nominally on channels below 5m in width; at the 1:1,250 scale it is for channels below 1m. To provide a reasonable measure of the true extent of water area represented by these lines we decided to allocate all non-determined widths of channels as 1m. In some cases this will overestimate and in others underestimate the true width.

The total extent of freshwater in Scotland RBD is estimated, using GIS, to be 186,661 hectares, comprising 138,557 ha of standing freshwater (i.e. lakes) and 48,104 ha of flowing freshwater (i.e. rivers).

The area of freshwater habitat in Scotland RBD for which obstacle data is available (see Map 3) totals 165,356 ha (42,060 ha of which is running water) (equivalent to 88.6 % of the total freshwater habitat in Scotland RBD (or 87.4% of running water habitat). We make the assumption that the impact of barriers on the freshwater habitat of Scotland RBD for which barrier data were available was representative of the ca. 12% for which data were not available. In fact it is likely that using the reduced data set leads to an overestimate of the impact of barriers, because there are no hydro-electricity schemes in the areas without data.

Within the subset of the RBD for which data were available (see Map 3) the total area of freshwater with natural access for migratory salmonids was measured at 134,700 ha (81.4 % of the total). The impact of natural barriers on running water habitat was similar to that on standing water bodies (Table 11).

The total area of naturally accessible habitat when also accounting for the impact of man-made impassable barriers was 84,103ha, representing 62.5 % of the area of naturally available habitat. Thus man-made impassable structures are estimated potentially to reduce the total habitat available to eels by 37.5 %. The relative impact of man-made impassable barriers was approximate twice as great on area standing water bodies available (42.4 % excluded) than on the area of available running water (23.1% excluded.)

Access from sea	Total freshwater habitat in Scotland RBD (ha)	Total freshwater area for subset of Scotland RBD for which barrier data available (ha)	% of area of full digital river network			% of area of 'naturally accessible' channels		
			Total	Still-water	Running water	Total	Still-water	Running water
To full digital river network	186,661	165,356	100	100	100			
Up to NI barriers	n/a	134,663	81.4	81.5	81.4	100	100	100
Up to MI barriers	n/a	84,103	50.9	46.9	76.9	62.5	57.6	76.9

Table 11. Estimated impact of barriers to fish movements on available eel freshwater habitat.

Undoubtedly there are reasons for supposing that eels and salmonids will experience obstacles to migration differently. Unlike salmonids, eels are not able to leap obstacles, and, according to Knights & White (1998) cannot negotiate vertical steps of greater than 50-60% of their body length. Elvers cannot swim against current velocities of > 0.5 $m.s^{-1}$, and although yellow eels may ascend at flows of up to 2.0 $m.s^{-1}$ (references in Knights & White 1998), fish passes for salmonids generally operate at somewhat higher velocities (Clay 1995).

Furthermore, it is well-known that eels are capable of travelling overland by using wet vegetation at the sides of the channel and so may bypass falls that are impassable to salmonids. Equally, small falls with an absence of surrounding ground that favoured eel-passage might be easily passed by salmonids but present impassable barriers to eels. Overall, for many cases concerning large barriers, the impacts on the upstream movement of salmonids and eels are probably qualitatively similar. Indeed, examination of the eel presence-absence data suggests that there is no striking mismatch between the distribution of barriers and the distribution of eels. 'Impassable' barriers tend to be associated with an absence of eels upstream, and eels are often detected above manmade barriers that are passable for salmonids.The true impact of 'impassable' barriers is likely to be substantially less than total habitat exclusion, as found at the Girnock Burn (section 2.4.1.2), but may be additive where multiple passable barriers occur.

Given the natural tendency for eel population density to increase with altitude/distance from the sea, the actual impact of barriers to eel migration should be less important than the foregoing analysis implies. When taking into consideration changes in productivity with altitude in the catchment (section 2.4.2.4), the reduction of productivity due to Manmade Impassable barriers was estimated to be at most 27.1%, rather than the 37.5% estimated purely in terms of area. It should be noted that the apparently greater anthropogenic impact on standing waters will be offset somewhat by the impassable barriers amongst the data set that were constructed to impound water (with the non-natural impounded water habitat being effectively (and incorrectly) regarded as 'lost' natural habitat by the foregoing analysis. It is not known how large this effect might be.

The Controlled Activities Regulations (CAR) 2005 http://www.opsi.gov.uk/legislation/scotland/ssi2005/20050348.htm#7 implemented by SEPA will address problems relating to habitat accessibility for eels. CAR allows licence reviews of existing barriers as well as licensing for new structures, and currently explicitly states that these must be passable for salmon and sea trout, which itself will tend to improve barrier permeability to eels. CAR also allows SEPA to consider all conditions relating impact of a barrier, including impacts on eel migration. Guidance notes relating to eels and river barriers for CAR licensing are currently being drawn up by SEPA.

2.5.7. Hydro-electric power

Alleviation of barriers to eel movements is generally uncontroversial, but with regard to hydro-schemes a different situation applies, for while eel passage upstream at hydroelectricity stations can be easily achieved, successful negotiation of the power stations in a downstream direction is much more problematic. The mortality due to downstream passage through hydroelectricity stations is not well known. It has been estimated at between 16-26% in the Meuse (Winter *et al* 2006) but is likely to be strongly influenced by the individual characteristics of hydro-schemes and dependent on eel size, with longer (probably female) eels being more likely to be damaged by passage through turbines (Larinier & Travade 2002). Indeed Mitchell & Boubee (1992) concluded that the survival of larger eels (>80cm) passing downstream through turbines in New Zealand was likely to be nil. The cost of retro-fitting intake protection facilities for eels on turbines is likely to be prohibitively high. However work in New Zealand has supported the value of allowing selective spillway openings during the peak of downstream migration (Watene & Boubee 2005). Downstream movement of silver eels is known to be influenced by flow and lunar cycles (Tesch 2003), but this has not been investigated in Scotland, In particular it is not known whether the downstream migration of eels in Scotland is sufficiently concentrated and predictable for intentional spillage at hydroelectric facilities to be a viable strategy in Scotland RBD.

As yet no measures have been taken to alleviate mortality at hydroelectric schemes in Scotland RBD, principally because this has not previously been a high priority option and is likely also to be expensive. However, recent developments may allow reconsideration. There has recently been a successful attempt to develop a system for allowing safe eel passage downstream by modifying an existing power station in New Zealand (Boubee & Williams 2006), using a combination of a surface spillway and a small diameter bypass in the dam face, although there are generally doubts that eels can locate and use surface spillways effectively. Though all such modifications will inevitably cause some loss of power generation, both the scale of silver eel mortality and the potential for alleviating this by improving downstream passage at hydroelectric installations in Scotland RBD could be explored. The Controlled Activities Regulations (CAR) 2005 http://www.opsi.gov.uk/legislation/scotland/ssi2005/20050348.htm#7 which, among other things, regulate river obstructions apply to hydro-schemes, but guidance is being developed by SEPA to require consideration of structures to allow eel migration will not apply to barriers which currently prevent eels from ascending above turbines through which they will have to pass on their seaward migration.

In the absence of direct data on silver eel mortality, the maximum potential size of the impact of hydro-schemes alone of eels in Scotland RBD was investigated. Information on the location of the most downstream points of power generation on the various Scottish hydro-electric schemes were obtained from Scottish and Southern Energy (SSE). The area of upstream habitat from which eels are either excluded by these schemes, or, worse, the area from which eels are not excluded and are therefore suffering mortality (at an unknown level) on downstream passage was estimated using the same GIS techniques and data sets as those described in the preceding section for river connectivity.

The total area of freshwater habitat available to eels was estimated to be 186,661ha. Since we did not have information on natural impassable barriers for all of Scotland we made the assumption that similar amounts of habitat were impacted by natural barriers in the areas for which data were and were not available on natural impassable barriers.

The total area of habitat from which eels are either excluded by hydro-schemes or from which they are exposed to turbine mortality represents 20.6% of total freshwater habitat (24.3% of still water, and 10.1% of running water) (Map 5). These percentages of area lost to eels from Hydro-power are reduced markedly when taking account of the distribution of natural barriers to eel migration to 3.4% (all freshwater), 8.1% (still water) and 1.3% (running water) if eels are regarded as being constrained by natural barriers thought to be impassable to salmonids (Table 12). These figures seem realitively low given the land area upstream of hydro-scheme barriers (Map 6), and are currently being reviewed. is the low values probably a cosequence of the siting of some hydro-schemes immediately below substantial natural barriers (ie waterfalls) to eel migration (in order to utilise the hydraulic head).

Access from sea	Total freshwater habitat in Scotland RBD (ha)	% of area of full digital river network			% of area of 'naturally accessible' channels		
		Total	Still-water	Running water	Total	Still-water	Running water
To full digital river network	186,661	100	100	100			
Up to NI barriers*	177,888	95.3	96.3	92.4	100	100	100
Up to Hydro-barriers	148,186	79.4	75.7	89.9	83.3	78.6	97.3

*based on average impact of natural impassable barriers for the area for which data were available (see Map 2)

Table 12. Estimated impact of hydro-electric schemes on eels: the percentage of freshwater habitat from which eels are either excluded or exposed to turbine-related mortality.

Some hydro-schemes have Borland Fish Lifts which permit eels to ascend to areas above turbines. However, there is substantial inter-connection between hydro-schemes catchments and therefore uncertainty about the routes taken by eels to regain the sea, it is not yet possible to assess the relative impact of habitat exclusion and turbine mortality for Scottish Hydro-power.

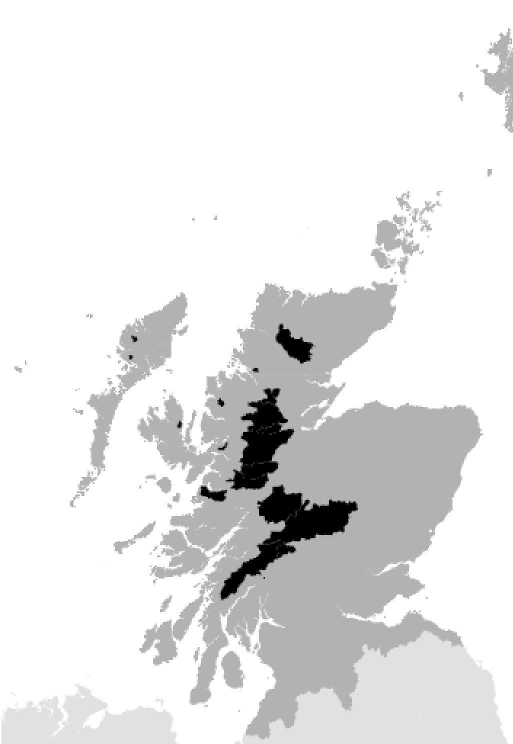
The estimated percentage of habitat excluded to eels by hydro-schemes is likely to overestimate their true impact on spawner escapement because

1) eel densities, and probably growth rates, decline with distance from the sea and hydropower schemes tend to be in the centre of the RBD (estimated impacted on production of hydro-schems is 3.6%, section 2.4.2.5)

2) a large but unknown proportion of the hydro-schemes simply exclude eels rather than cause direct mortality. If recruitment is low and habitat saturation is low, then

the increase in population density downstream consequent on the presence of an impassable barrier may be insufficient to incur high density dependent costs on eels. In other words the impact of habitat exclusion on eel production will be positively related to population density.

3) Some production may occur where Borland lifts allow eel access if mortality from passage through turbines is less than 100%



Map 6. Area potentially impacted by hydro-power schemes in Scotland RBD: catchments from which eels are either excluded, or exposed to turbine-related mortality are shaded in black. NB eels are naturally excluded from an unknown portion of the shaded region.

2.5.8. Summary

Estimated effects of these various threats to eels in Scotland RBD are summarised in Table 13. These are mostly qualitative, reflecting the vague state of current knowledge. Where figures are used data are also weak, and the values should be regarded with considerable circumspection.

	Qualitative/semi-quantitative impact/mortality on eels mortality for each life stage		
	Glass eel	Yellow eel	Silver eel
Habitat loss (% impact)	0	< 30%	< 30%
Parasites (% affected)	?	small	small
Pathogens (mortality)	?	small	small
Pollutants (%mortality)	?	small	small
Predators (mortality)	?	Moderate	Moderate
Turbines (% affected)*	0	<5%	<5%

***impact either through direct mortality or via habitat exclusion and associated density dependent increase in mortality**

Table 13. Estimated percent of Scotland RBD eels affected by various threats.

3. Restocking

No stocking of eels is thought to have occurred in the past in Scotland RBD and there are no plans to implement any stocking in the future.

The potential benefits of stocking relate to reduced natural mortality in high density donor locations, improved habitat saturation in otherwise low density areas and greater recruitment of female spawners due to improved growth at lower average densities. Given the exponential nature of the decline in eel population density with distance from the sea, it is highly unlikely that any but the lower parts of catchments are at or near saturation densities. There is evidence from continental Europe for an important role for stocking in supporting declining populations (Tesch 2003). The likely utility of stocking is not clear in all circumstances (Shiao *et al* 2006), since there is some evidence that the migratory performance of stocked eels may be poor (Westin 1998, 2003).

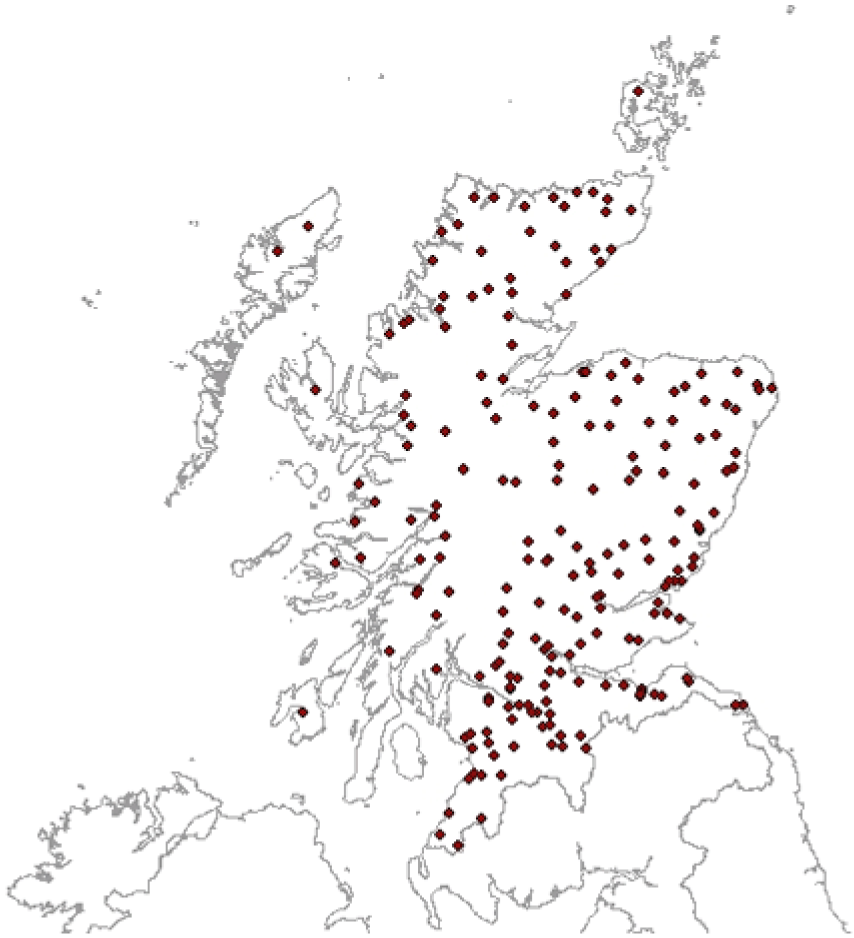
In addition, there are two associated concerns: firstly the parallel translocation of diseases of eels and potentially other fish species or other invasive non-native species and secondly a potential for a negative impact on salmonid populations (Tesch 2003), particular via egg consumption. Additionally, while there is a current consensus that European eels represent a single panmicitic stock, this has not yet been established beyond all doubt, and so, if consistent with achieving the 40% escapement target, stocking should be avoided. Given these risks, and given current low estimates of recruitment throughout Europe as a whole (suggesting density dependent mortality is not currently high and that stocking is therefore likely to have little positive impact overall), there appears to be no strong case for stocking young eels in Scotland RBD at this stage.

Furthermore, fishing for elvers is not permitted without a licence in Scotland RBD, and there is a strong presumption against the granting of such licences (section 5.1)

4. Monitoring

4.1 Assessment of silver eel escapement

A monitoring program of freshwater fish populations in Scotland's rivers, beginning in summer 2008, has been instigated by SEPA under the Water Framework Directive. Approximately 210 sites in Scotland RBD will be electrofished (3 pass or 1 pass) over a 6 year rolling program (around 30-40 sites per year) (See Map 7). These are multi-species surveys, and although nominally "fully quantitative" are likely to underestimate the true density of eels (Knights *et al* 2001). In addition, the standing stock of eels on on the Girnock, Baddoch and Shieldaig catchments will be assessed (using 3-pass electrofishings at a minimum of 6, 3 and 5 sites respeectively) and related to silver eel escapement estimated from downstream trapping. Using area-based assessment of eel habitat (from GIS) these two sources of data will be used to generate a broad estimate of the biomass of silver eel escapement. It is unrealistic at this stage to generate estimates of error in this process, but these are likely to be large (though quantifiable). In addition the 6-year rolling monitoring program will form the start of a data set with which to assess temporal changes in the standing stock of eels in Scotland RBD.



Map 7. Distribution of sites (n=210) in Scotland RBD to be electrofished by SEPA on a 6-year rolling program. Three-pass electrofishings targeted at all fish species.

Developments in eel population models across Europe will be reviewed, and appropriate models will be deployed. In particular the Scenario-based Model for Eel Populations (SMEP), being developed by the Environment Agency, will be used to assess compliance with the EC target. SMEP uses an age and length structured population data to model to simulate the estuarine/freshwater phase of eel production in the UK. SMEP can incorporate both the biological characteristics of eel production and (e.g. growth, natural mortality, sexual differentiation, maturation and migration) and a number of potential anthropogenic factors e.g. habitat quality, fishing, barriers and stocking. It can be applied at the catchment scale, and can handle a range of data detail which may be appropriate to the data to be collected in Scotland RBD. It is hoped that compliance with the 40% of natural escapement target will be assessed in the 2012 reporting round using the SMEP, however the level of error associated with the model is presently unknown, and, given limited data that will be available from Scotland RBD, likely to be large. It is proposed that SMEP be tested in the Girnock Shieldaig and Baddoch catchments, and its suitability for use as an assessment tool be determined.

In the meantime, the analyses presented in Section 2.2, provide no compelling evidence for a declining trend in yellow eel stocks over the period between 1997 and 2005 while analysis of current silver eel escapement (section 2.4) suggest the spawner escapement in Scotland remains above target of 40% of pristine escapement. It may be that Scotland

RBD's proximity to the continental shelf and the marine migratory routes for juveniles has maintained a relatively high level of glass eel recruitment. Unfortunately there is a dearth of information covering the critical period immediately following the collapse of glass eel recruitment in Europe. However, the slow average growth of eels in Scotland RBD suggests that if a decline in elver recruitment to the Scottish RBD had occurred in the 1980s its effects would be expected to be detectable among yellow eels during the present period.

Although the assessments described above have not detected declining trends in abundance, given data limits on the power of the analyses, it is worthwhile considering possible anthropogenic effects on spawner recruitment independently of the assessment data (section 2.4). However this consideration leads to a conclusion that anthropogenic influences on eels in Scotland RBD are likely to fairly small, the most important currently being barriers to eel movement, and that therefore if there are substantial anthropogenic effects on silver eel escapement in Scotland RBD that these must be principally due to changes in glass eel recruitment not related (at least not directly) to human-activity within Scotland RBD.

4.2 Price monitoring and reporting system

Regulation of the eel fishery in Scotland will be instituted for the first time in Scotland, early in 2009, with the legal requirement that fishing for eel by any method is prohibited without a licence granted by Scottish ministers. It is presently uncertain whether any applications for eel-fishing licences will be submitted to, or, if submitted whether any will be granted by Scottish ministers. Accordingly there is as yet no system in place for monitoring and reporting of eel prices in Scotland RBD, and may be no need for one.

Nationally in the UK, the present price monitoring is carried out from an analysis of export and import data and ad hoc enquires to the industry. It is proposed that this system be maintained. In this assessment of price it is realised that it is not the price the fishermen are being paid for their catch that is being monitored but the resale price to the consumer. The price will be reported annually as part of the ICES/EIFAC assessment of eel in the UK country report.

4.3 Catch and effort sampling system

Regulation of the eel fishery in Scotland will be instituted for the first time in Scotland, early in 2009, with the legal requirement that fishing for eel by any method can only be permitted under a licence granted by Scottish ministers. It is presently uncertain whether any applications for eel-fishing licences will be submitted to, or, if submitted whether any will be granted by, Scottish ministers. Accordingly there is as yet no system in place for monitoring and reporting of catch and effort in Scotland RBD, and there may be no need for one. Guidance to ministers states that, in the highly unlikely event of a licence being granted for commercial exploitation of eels one of the conditions for its issue will be a full reportage of the number and size of eels caught, and effort taken, under it. This arrangement is stated to last for the lifetime of Scotland RBD EMP, and the licensed catch of eels of all stages will be reported in future EMPs.

4.4 Origin and traceability of live eels

Traders in eel for live stocking must keep and supply the Fish Health Inspectorate of Cefas with details of movement and mortality records, including movement of dead fish. Movement records should be such that the origin and destination of the consignment of aquatic animals can be traced. It has yet to be agreed with the eel industry whether it is possible to separate and quarantine different stocks.

The origin of catch within the UK will be available through the catch return system and from the Fish Health Inspectorate records these can then be compared with the management actions identified in the agreed eel management plan for the respective RBD and with CITES. This will enable the management authority to determine whether or not eels harvested and exported outside the Community area were caught in a manner consistent with Community conservation measures.

The origin of catch from outside the UK but imported into the UK will be available from the Fish Health Inspectorate records. These can then be compared with the management actions identified in the agreed eel management plan for the respective RBD and with CITES. This will enable the management authority to determine whether or not eels imported into the UK were caught in a manner consistent with that of the regional fisheries organisation in question.

5. Measures

5.1 All measures

Eel fisheries

The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008 was advertised on 22nd August 2008, closed for consultation on 21st November 2008 and became law on 26th January 2009. This measure is being adopted under powers already available to Scottish Ministers under the Aquaculture and Freshwater Fisheries (Scotland) Act 2007. The Regulations were made under section 51A of the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. The effect of the Regulations is to prohibit fishing by any method for eels (*Anguilla anguilla*) in Scotland, except on application and under the authority of a licence granted by Scottish Ministers.

Given the level of concern throughout Europe at eel mortality, the guidance provided by the Scottish Government regarding application for any licences states that it is “highly unlikely” that any licences would be granted to fish commercially for eels, and particularly for eels < 12cm, though licences may be granted for small scale research work. This arrangement is stated to last for the lifetime of Scotland RBD EMP.

Scotland has no known commercial eel fishery. However there may be some low-level recreational fisheries for eels and it is these the regulation will control, and such fisheries are now highly unlikely to be permitted on application for a licence to Ministers. It would be contrary to the objectives of the Eel Management Plan and the conservation measures being sought for any new fishery for eels to develop in Scotland. The introduction of this new regulation provides measures not currently available to Ministers to control that.

River connectivity

The Controlled Activities Regulations (CAR) 2005 implemented by SEPA as part of the WFD http://www.opsi.gov.uk/legislation/scotland/ssi2005/20050348.htm#7 will address problems relating to habitat accessibility for eels. CAR allows licence reviews of existing barriers as well as licensing for new structures, and currently explicitly states that these must be passable for salmon and sea trout, which itself will tend to improve barrier permeability to eels. CAR also allows for the development of new conditions, and SEPA are currently developing guidance relating to promoting eel migration in CAR.

Further measures to alleviate barriers to eel movements are being instituted under the River Basin Management Planning Process Restoration Fund, operated by SEPA. Projects recommended for funding 2008/2009 included 8 which either removed or alleviated potential barriers to eel migration at a cost of £50,000. Applicants for restoration funding currently being considered (2009/2010) which are scoping or designing a fish pass will be asked to include eel passes, and applicants for projects for installing fish passes where the fish pass design has already been specified will be asked to consider if an eel pass can be incorporated. For the year 2009/2010 £700,000 are available, the majority of which is likely to be spent on barrier alleviation. For future funding rounds guidance for restoration fund applicants considering alleviation of barriers will encourage all species of fish to be considered, and specifically highlight eels. It will be expected that future project applications to the restoration fund addressing fish movements will specifically consider eels, and that this will be incorporated into the assessment process for awarding funding.

In addition Marine Scotland will encourage River Fisheries Trusts to alleviate barriers for eels, and provide guidance on eel pass design to managers. Thus far two eel passes have been installed in this way.

Hydro-electric power
The Controlled Activities Regulations (CAR) implemented by SEPA (2005) which among other things regulate river obstructions apply to hydro-schemes, but changes to CAR being activated by SEPA to require consideration eel migration will not apply to barriers which currently prevent eels from ascending above turbines through which they will later have to pass on their seaward migration.

Contaminants in eels.
From 2009 onwards SEPA will assess various contaminant loadings in eel muscle tissue from up to 120 eels, collected from about 200 sites in Scotland RBD (see Map 7), in each of the years from 2009-2013. Marine Scotland Science (MSS)will age the eel using otoliths.

Eel parasites and pathogens
SEPA will sample up to 120 eels in each years from 2009-2013, collected from about 200 sites across Scotland RBD (see Map 7). The swimbladders of these fish will also be examined by MSS to determine the presence or absence of *Anguillicoides crassus*, and establish the extent of the spread of the parasite.

5.2 Measures implemented in the first year of the plan

- *The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008* is currently being advertised, and is likely to be in place by early 2009 and thus expected to be implemented during the first year of this management plan. For further details see Section 5.1.

- Barrier removal/alleviation improving eel access in 2008/2009 supported by River Restoration Fund

Cunning Burn Weir, Sawmill Croft, to be removed.
Auchenbadie Burn Weir, to be removed.
Fishrie Burn Weir, Mains of Balmaud Farm, to be removed
Braenaloin Weir, Braenaloin Burn, River Dee, to be removed.
Crammie Weir, Feugh, River Dee, bypass channel to be enhanced.
Mill of Crammie Weir, Feugh, River Dee, to be removed
Crynoch Weir, River Dee, bypass channel to be enhanced.
Drumwheels obstruction, River Dee, barrier alleviation

- Large proportion of £700,000 from River Restoration Fund likely to be spent on barrier removal/alleviation with specific consideration of eel.
- CAR regulations implemented by SEPA as part of WFD relating to new and existing in-river structures permit consideration eel migration following consultation. Guidance notes being developed.

5.3 Time period for the achievement of the escapement target.

At present our best estimate is that Scotland RBD is attaining at least 46% of potential spawner escapement in the absence of human pressures on the stock (based on the analysis in Section 2.4). We cannot attach realistic measurement errors to this estimate however. We aim to reassess this figure, and provide some estimate of error in current spawner escapement measures in the light of new monitoring data for the next Scotland RBD EMP of 2012.

Description of all measures taken in accordance with Articles 2(8) and 2(9) of Regulation (EC) 1100/2007
Below are listed the measures to be taken in Scotland RBD under headings laid out in Article 2(8) of the Regulation (EC) 1100/2007, together with the associated measures to be taken in Scotland RBD and their categorization as short- medium- or long-term

a) *Reducing commercial fishing activity*
   - Fishing by all methods to be prohibited without a licence see section 5.1. From 2009.

b) *Restricting recreational fishing,*
   - Fishing by all methods to be prohibited without a licence see section 5.1. From 2009.

c) *Structural measures to make rivers passable and improve river habitats, together with other environmental measures.*
   - Controlled Activity Regulations of the WFD implemented by SEPA to include consideration of fish migration for new and existing structures in rivers. Guidance notes specifically for eels currently being prepared by SEPA

   - River restoration funding (under River Basin Management Planning process) will incorporate guidance and expectation that all future barrier alleviation will specifically consider eels, from 2009. Up to £700,000 available.

   - River Fisheries trusts to be encouraged (and provided with guidance where necessary) in the alleviation of barriers to eel migration.

d) Hydro-electric power turbines

- Controlled Activity Regulations of the WFD implemented by SEPA to include consideration of fish migration for structures in rivers. Guidance notes on specifically for eels currently being prepared by SEPA.

6. Control and Enforcement

Regulation of the eel fishery in Scotland will be instituted for the first time in Scotland, early in 2009, with the legal requirement that fishing for eel by any method is prohibited without a licence granted by Scottish ministers. It is presently uncertain whether any applications for eel-fishing licences will be submitted to, or, if submitted whether any will be granted by Scottish ministers. Accordingly there is as yet no system in place for monitoring and reporting of catches.

Detection and prevention of unlicensed fishing for eels will be enforced by Scotland’s Water Bailiffs and Scottish Police Force Wildlife Crime Officers.

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