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Eel Management plans for the United Kingdom

Overview for England and Wales

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1. Overview

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, 2006).

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.

Across England and Wales, the EMPs will be set at the River Basin District (RBD) level, as defined under the Water Framework Directive. The aim of each 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.

1.1 Compliance With Council Regulation (EC) No 1100/2007

1.1.1 Competent Authorities in England and Wales

- Department of Environment, Food and Rural Affairs (Defra)
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)
- Environment Agency
- Welsh Assembly Government (WAG)

In England and Wales eel legislation and policy is determined by the Governments, through the Department of Environment, Food and Rural Affairs (Defra) for England and the Welsh Assembly Government for Wales. Delivery of eel regulation and management in inland waters and in tidal waters to a distance of 6 nautical miles, is the responsibility of the Environment Agency. Further details are provided in Appendix 1.

1.1.2 Description of Management Units

In accordance with the recommendations set out in the Regulation, River Basin Districts (RBDs) developed for the Water Framework Directive (WFD) have been set as management units (Figure 1).

1.1.3 Legislation

An outline of the current legislation in place and what will be introduced, e.g. through byelaws etc, to meet our obligations under the EU Regulation. Again this can be separated into the England and Wales, Scotland, and Northern Ireland.

Where fisheries are shown to be affecting eel populations beyond a level that complies with the European Regulation, the Environment Agency has the powers to bring in a byelaw to limit the fishery by reducing season length. At present, the Agency cannot refuse a licence or restrict where fishers can and cannot fish within the existing boundaries. The Environment Agency is currently seeking powers in the Marine Bill to be able to limit the number of fishermen. This is detailed in Appendix 2 for England and Wales.

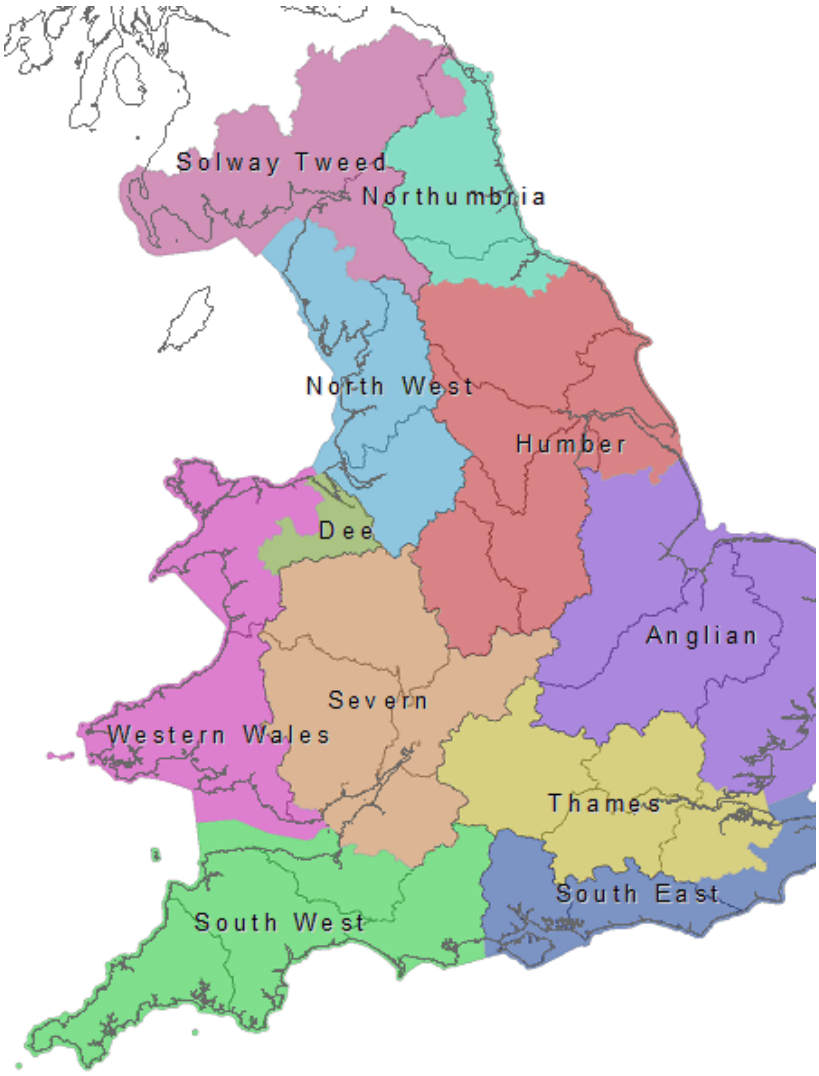

Figure 1. Water Framework Directive River Basin Districts used for Eel management plans in England and Wales

1.1.4 Compliance with Articles 2-12 of Regulation EC 1100/2007

Article 2 – Establishment of Eel Management Plans

- Eel management plans have been developed for each River basin District in England and Wales and for the Solway Tweed RBD (section 1.1.2).
- For this phase of the EMPs compliance with the escapement target has been carried out through a comparison with historical data (approach a) on RBDs where these are available, and a modelling assessment (combining approaches b and c); (described in section 1.3.2.2 and Appendix 3).
- Details of the measures to increase silver eel escapement are presented in each EMP and outlined in section 1.4, the time schedule in section 1.4.7 and details of control and enforcement in Appendix 12.
- Monitoring details are presented in each EMP and in sections 1.3.3.1, 1.6.1 and 1.6.2

Article 3 – Exemption from the obligation to prepare an Eel Management Plan.

- Not applicable

Article 4 – Communication of Eel Management Plans

- The eel management plans will be submitted to the Commission for approval by December 31st 2008.

Article 5 – Approval and implementation of Eel Management Plans

- Once the plan has been approved by the Commission it is proposed to implement it from July 1st 2009, or earlier if approved before this date.

Article 6 – Transboundary Eel Management Plans

- Not applicable for these plans that which cover England and Wales and the Solway Tweed River basin District which is cross border between England and Scotland.

Article 7 – Measures concerning restocking

- Details of the stocking requirement have been estimated for each EMP which has been assessed as failing the escapement target. The method used to estimate stocking requirement and guidelines for stocking are presented in Appendix 7.

Article 8 – Measures concerning community waters

- Not applicable, see section 1.2.4. Marine Fisheries.

Article 9 – Reporting and Evaluation

- It is proposed to report to the Commission by June 30th 2012 in accordance with the Regulation.

Article 10 – Control and enforcement in waters other than Community water.

- Details of the monitoring set out in Regulation (EEC) No. 2847/93 is presented in Appendix 11 and catch monitoring in Appendix 9.

Article 11– Information concerning fishing activities

- These are detailed in Appendix 11.

Article 12 – Control and enforcement in waters concerning imports and exports of eel

- These are detailed in Appendix 10.

1.2 Eel fisheries in England and Wales

Eels are common throughout England and Wales (Maitland, 2004) and have long been exploited. There is evidence from the *Domesday Book* (Anon. 1086) of extensive eel fisheries in the Thames, which persisted up until the end of the 19th century (Naismith & Knights, 1993). The fishery today is much reduced and confined to the estuary (Thames RBD). Surveys conducted by the Environment Agency show eel to be present in nearly all river systems, although there are some areas where they are scarce or absent, particularly the upper reaches of rivers. In addition, the lower reaches of some rivers also appear devoid of eel although the species is present further upstream.

All life stages of eel are exploited in England and Wales (Figure 2). The main fisheries for glass eel (<120 mm) employ dip-nets in estuaries, primarily in those rivers draining into the Bristol Channel, notably the Severn and Wye in the Severn RBD; the Parrett in the South West RBD; and also in smaller fisheries in several RBDs, such as that in Morecambe Bay in the Northwest RBD (Knights *et al.*, 2001). As the eels caught by these fisheries are <120 mm, the catches will be subject to Article 7 of the Regulation, and a proportion of the catch will be made available for stocking. Other than the glass eel fisheries, there is a minimum legal landing size for eel of 300 mm in England and Wales.

The main fisheries for eel >300 mm are based in lowland areas in the southern and eastern England within the Humber, Anglian, Thames and South West RBDs, with fyke nets being the preferred method for capturing yellow and silver eels.

1.2.1 Allocation of fishing effort

Licences to fish for eel in England and Wales with nets and traps are sold by the Environment Agency and issued on a Regional basis (see Appendix 2 for organizational structure). Since 2005, licensees are required to provide annual catch returns, detailing the month, water type (coastal, river, stillwater), location, nearest town, number of days and number of instruments fished and the total weight of eels caught (glass, yellow and silver stages separately).

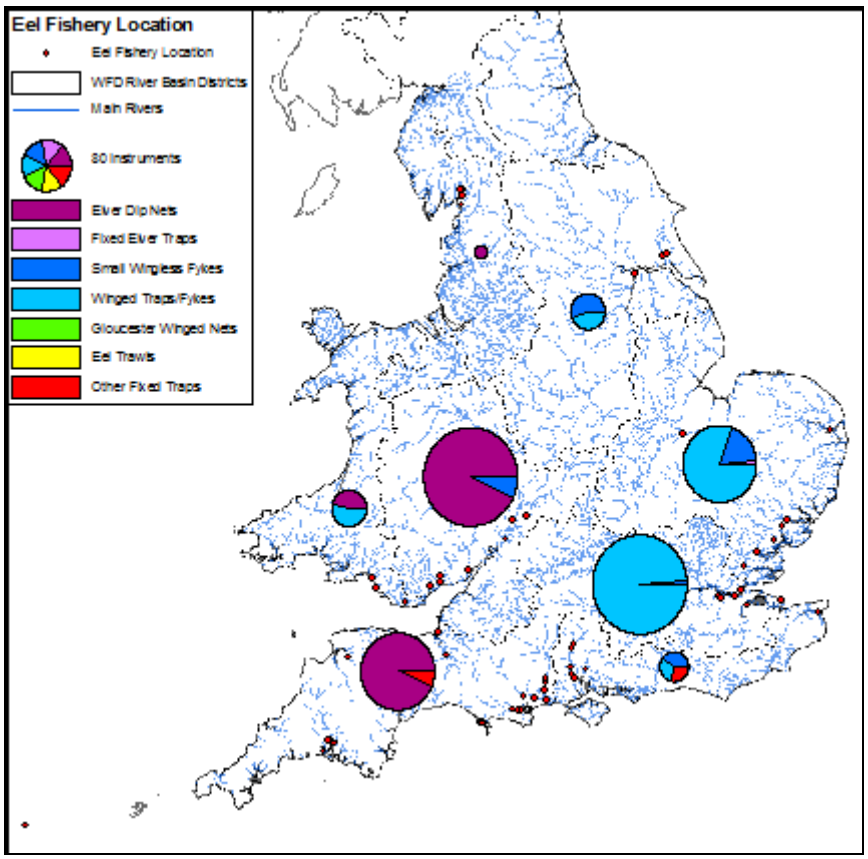

Figure 2. Location of eel fisheries in England and Wales.

1.2.2 Description of fishing effort

In each EMP, the size of the fishery is presented in terms of the number of licensed instruments as opposed to the number of licensed netsmen. This is because licences are issued for gears rather than to named individuals: one fisherman is able to set many traps and/or fykes. The only fishing gears operated by a single person are dip nets, fixed traps, and Gloucester Wing Nets. As a consequence, fishery size should better reflect potential effort. However, as the administrative management unit for eel net licensing is the Environment Agency Region, rather than the RBD, it is not possible at present to provide a definitive description of fishery size for several RBDs. For example, it is believed that >90% of the UK glass eel catch is derived from the Severn RBD.

Prior to 2005, no specific effort data were associated with these catch data, and catch per licence has been the only proxy for CPUE available to eel fishery managers. However, comparison of catch data with information on nett eel exports for England and Wales from HM Revenue & Customs (HMRC) suggests a significant level of under-reporting, by between 5 and 15 times for glass eel and about 6 times for yellow and silver eel combined, with rates differing from year to year. As such, these data can only provide proxy estimates of recruitment and of home and international market trends (Knights *et al.*, 2001; Knights, 2002). The under-reporting of catches needs to be addressed and the quality of data improved. The opportunity to achieve this may be resolved through the CITES Appendix II/Annex B listing for *Anguilla anguilla* coming into force on 13th March 2009 (see also section 1.4.1).

1.2.3 Glass eel.

In England and Wales glass eel are caught using dipnets (Figure 3). The trends in glass eel catches, as reported to the Agency, and as estimated from HMRC nett export data is shown in Figure 4a. There has been a general decreasing trend in both glass eel catches reported to the Agency and in HMRC nett export data. Considerable between-year variations in these data preclude meaningful analyses based on running period means. However, simply comparing maximum catch levels in the late 1970s - early 1980s with minimum levels in the 2000s suggests that the catch reported to the Agency has declined by 98% and the HMRC nett exports by 75%.

Figure 3. **Dip net fishing for glass eel on the Rivern Severn (Photograph courtesy of UK Glass eel Ltd.)**

Trends in glass eel recruitment are likely to be better indicated by catch per unit of fishing effort (CPUE) than by reported catch alone, since there are a number of factors that will have affected effort during the time series. Glass eel/elver fishing effort is not directly quantified in the UK, but annual licence sales data from the Environment Agency and predecessor agencies provide an index from which changes in effort over time can be inferred, since each licensee is likely to fish the same number of suitable tides over the short season each year (February – May).

The variable, apparent under-reporting of glass eel/elver catches to the Agency precludes a meaningful analysis of CPUE from Agency data alone. The HMRC data are also limited in value, because the trade statistics do not differentiate between life stages, and trade in

glass eel is inferred from unit value calculations: for live and chilled eel, unit values >£200 per kg are assumed to be trade in glass eel. Discussions are currently underway with Customs and Excise to address this and it is hoped that specific export / import codes will be developed which will facilitate reporting by life stage.

Trends in CPUE (as kg/net licence sales) derived from reported catch or nett exports are similar (Figure 4b), at least until 1998 (correlation coefficient: 0.62). Both indices show declining trends throughout the 1980s and 1990s, similar in magnitude to those of reported catch and HMRC nett exports: 98% for reported catch and 85% for nett exports. In contrast, both indices show increases from 2002, by about 3 times to 2006.

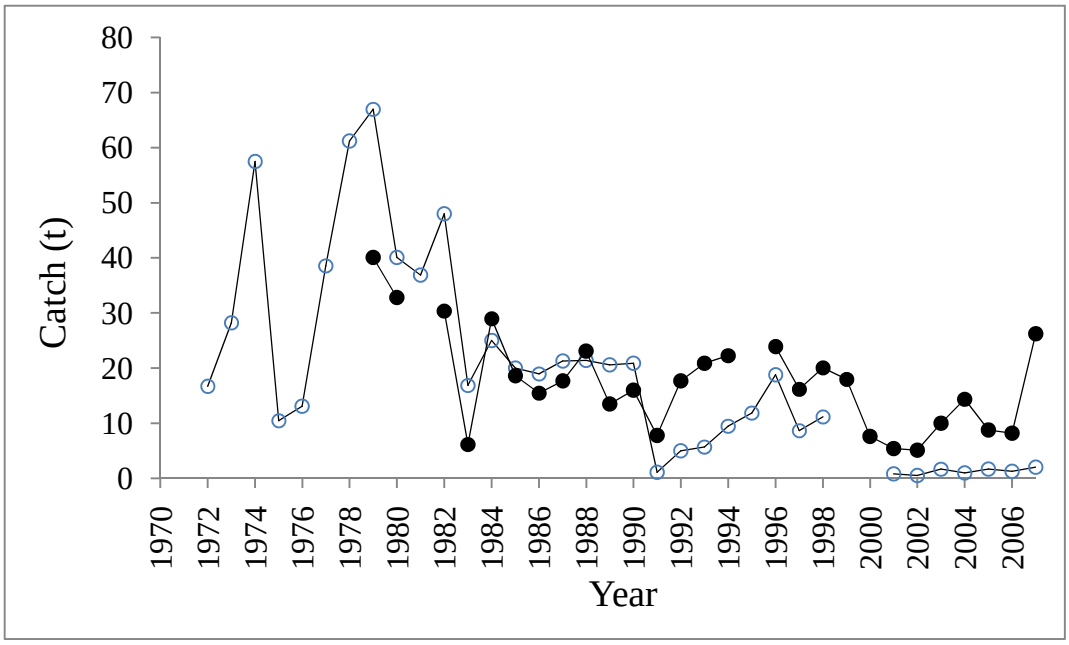

Figure 4a. **Trends in UK glass eel/elver catches reported to the Environment Agency in tonnes (open circles), and derived from HMRC nett export data (closed circles) from 1972 to 2007.**

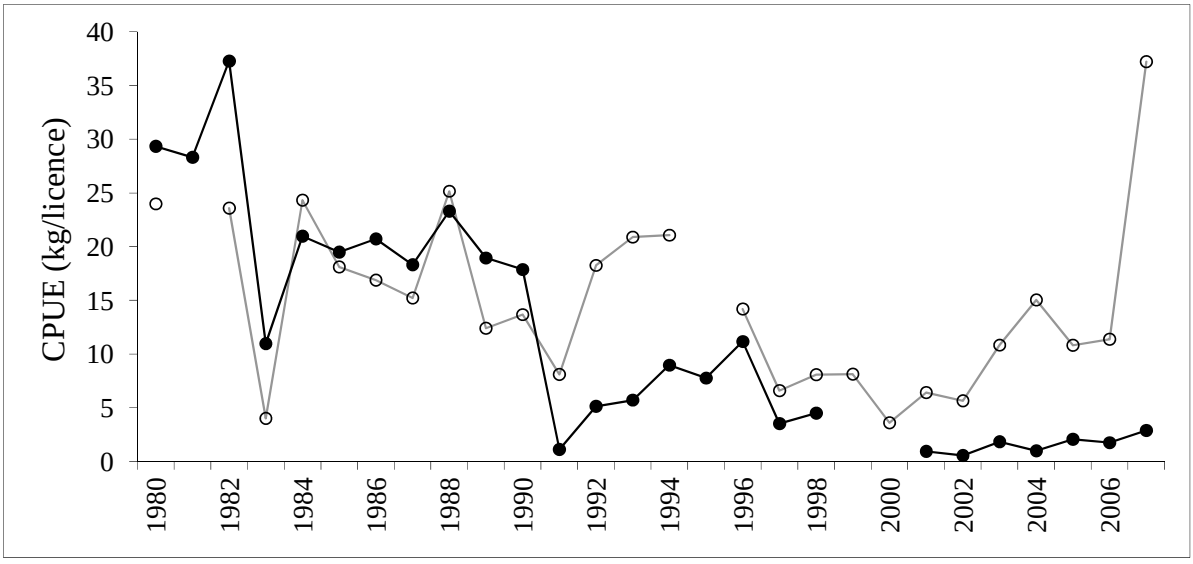

Figure 4b. **Trends in UK glass eel/elver fishery CPUE, derived from HMRC nett export weight (kg) against Environment Agency net licence sales (open circles), and from catch reported to the Environment Agency against net licence sales (closed circles) from 1980 to 2007.**

It is concluded that current glass eel recruitment to the western coast of the UK is approximately 30% of the pre-1980 level of recruitment.

1.2.4 Yellow and silver eel fisheries

Prior to 2005, licensed fishermen were not required to separately report catches of yellow and silver eels. As such, most fishery data are for combined catches of both stages. Annual catch returns to the Environment Agency for yellow and silver eel fisheries (combined) have averaged 25.8 t over the period 2003-2007, and have been at a low level since 2001 compared to the late 1980s and mid 1990s (Figure 5a). The annual HMRC nett export of yellow and silver eels averaged 125.6 t over the period 2003-2007, and show the same trends. As with the glass eel/elver reports, these data suggest that the Agency catch returns are likely underestimates of the true catch.

As with glass eel/elver data, estimating CPUE for English and Welsh yellow and silver eel fisheries is problematic because of concerns about regarding under-reporting, but indices derived from HMRC nett exports or reported catches per licence sold both suggest relatively consistent CPUEs in the late 1980s and mid 1990s, with a decline of about 80% from then onwards (Figure 5b).

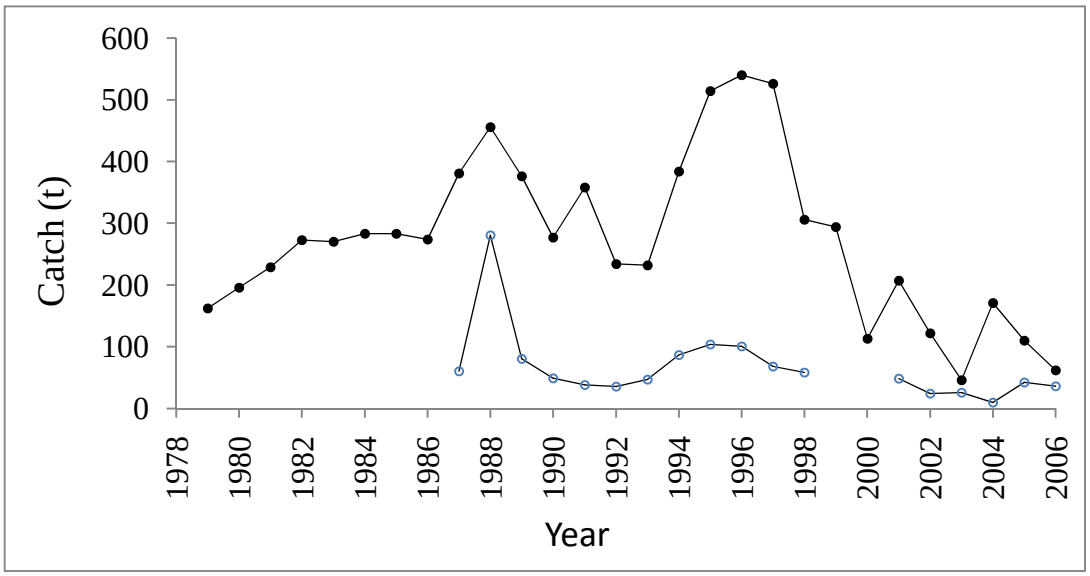

Figure 5a. **Trends in yellow/silver eel catches reported to the Environment Agency in t (open circles), and derived from HMRC nett export data (closed circles) from 1979 to 2006.**

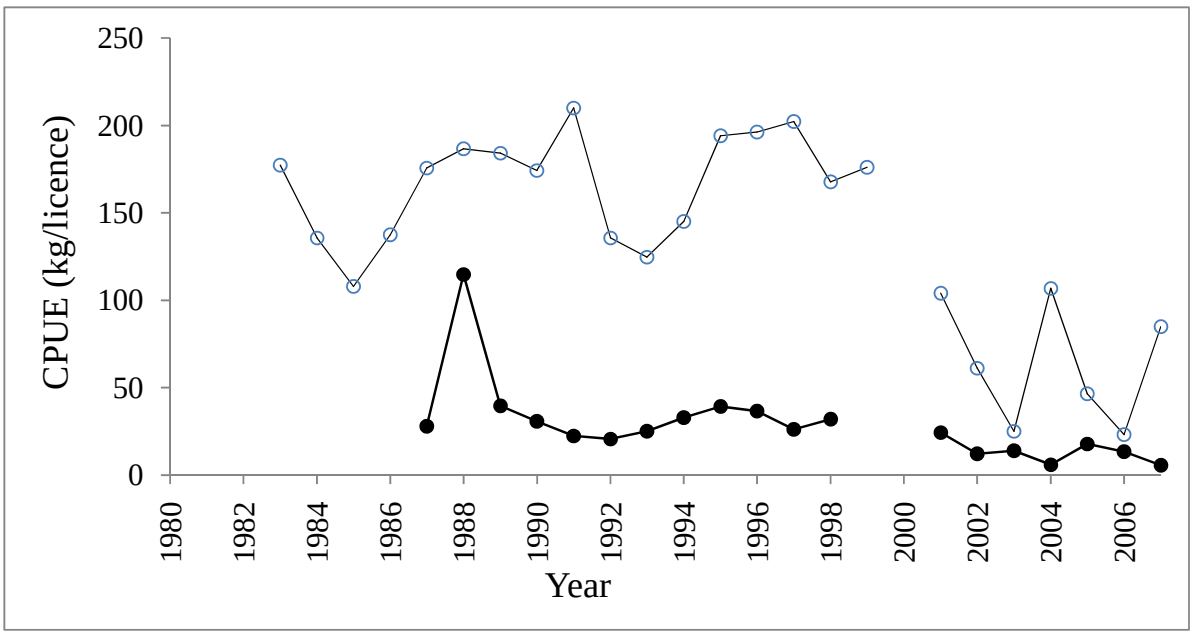

Figure 5b. **Trends in England and Wales yellow/silver eel fishery catch per unit effort, derived from HMRC nett export weight (kg) against Environment Agency net licence sales (open circles), and from catch reported to the EA against net licence sales (closed circles) from 1983 to 2007. Note that licenses are required for each fixed trap and for each net-end, and therefore the number sold is considerably greater than the number of 'licensed' fishermen.**

1.2.5 Marine fisheries

Those fisheries in coastal and transitional waters that are targeting eel (i.e. a licence has been taken out to fish for eel) will be included within the EMP. It will not include those fisheries where eel forms part of the by-catch.

There are no fishing vessels licensed specifically to fish for eel in community waters.

1.3 Interpretation of the target

The management target has been defined as 40% of the potential biomass of silver eel that would have escaped from any eel-producing habitat, in the absence of anthropogenic influences. Three immediate challenges, therefore, are to decide 1) what constitutes eel-producing habitat, 2) what historic level of recruitment should be considered optimal (i.e. free from anthropogenic influences), and 3) what weight of silver eel would be produced from each management unit under these optimal conditions?

1.3.1 Eel-producing habitat

There are 11 RBDs in England and Wales (Figure 1). Preliminary estimates based on WFD-GIS datasets suggest similar surface areas of potentially eel-producing habitat in rivers and lakes in England and Wales (about 618 km^2 each). This analysis did not take account of the effects of obstacles to migration of eels, because spatial data on potential obstacles are not yet available for all RBDs. The amount of potential eel habitat includes

those areas of the catchment upstream of impassable man-made barriers, but excludes areas upstream of impassable natural barriers. Although such data are available for the Scotland RBD, this has yet to be quantified for England and Wales (and Northern Ireland), but the plan is to undertake this work over the next three years, by 2012.

Otolith microchemistry analyses of European and other eel species suggest that eels may settle in estuaries and in freshwater, and may move back and forth between these habitats to a variable extent (e.g. Arai *et al*., 2006). Thus, estuaries may be an important source of eel production from many river basins, especially now when recruitment is probably insufficient to drive eels far into freshwater, or where barriers (physical or chemical) limit upstream migration. According to the WFD boundaries there are 2694 km^2 of Transitional Waters (estuaries and some parts of the adjoining coastal waters) in England and Wales, which constitute about 68% of the potential eel-producing habitat across all 11 RBDs. However, information on the relative production of eel in UK estuaries and coastal waters compared to freshwater is sparse. For these first phase plans the potential eel-producing habitat in Transitional Waters has not been included in the assessment of compliance with the escapement target unless a time series of information exists where current stocks can be compared with historic stock levels (i.e. Thames RBD).

The Regulation suggests determining the target level of escapement based on the potential eel production, in the absence of anthropogenic mortality factors. However, in relation to barriers the vast majority of obstructions have been in place and impacting on the eel stock prior to the collapse in glass eel recruitment in 1983/84. Thus the amount of eel-producing habitat available during the period of high and relatively stable recruitment (1950-1980) could be considered optimal.

1.3.2 Optimal historic level of recruitment

In the absence of a stock/recruitment relationship that can be applied at the RBD or EMU scale, and the very limited number and distribution of recruitment series in Europe, ICES and the Commission have taken a pragmatic view that the potential production of silver eels (the spawners) from available habitats during the 1950s to 1970s, when stock-wide recruitment was fairly stable at historically high levels, represents a practical basis on which to develop a biological reference point aimed at the recovery of a sustainable stock.

Water quality has improved in many UK river basins in the past 30 years, so river basins today may provide more potentially productive eel habitat and fewer water-quality-based impacts on production than were present in the 1950s to 1970s. For example a number of the principal salmon rivers have recovered (e.g. River Tyne) or are recovering (e.g. River Tees, River Mersey and the Yorkshire Ouse system) from the effects of pollution and major industry during the early part of the 20th century such that they now again support salmon fisheries (Mawle and Milner, 2003). Thus, the target silver eel escapement might be achieved from a lower level of recruitment than required previously. However, our knowledge of eel production processes is not sufficient to quantify the required recruitment level.

1.3.3 Methods to estimate silver eel production

Despite the extensive history of eel fishing in the UK, data on eel stocks in most rivers are limited to accounts of their presence/absence or relative abundance derived from multi-species surveys (Knights *et al*., 2001). There were no rivers in England and Wales (or Scotland) where annual silver eel escapement biomass has been quantified. In the

absence of appropriate and robust historic data on silver eel escapement, yellow eel data has been used as a surrogate for silver eel production in England and Wales to assess compliance with the target.

1.3.3.1 Sources of data

Glass eel

There is little fishery-independent quantification of glass eel/elver recruitment to UK estuaries. Fishery-independent surveys of glass eel/elver are undertaken at two sites in Anglian, at two sites in South West and at one site in North West RBDs. However, the surveys do not allow a quantification of the recruitment, the time series of data are not extensive and do not extend to pre-1980, before the crash in recruitment.

Yellow and silver eel

As the target has been defined in terms of the weight of silver eel escaping from each management unit, the most direct method by which to assess compliance would be to capture and weigh emigrating silver eels. However, there are few rivers in England and Wales where silver eel fisheries operate or where facilities are available to trap silver eels on their downstream migration, and the installation and operation of new traps is restricted financially.

In contrast, yellow eels are captured during multi-species electric fishing surveys conducted annually by the Environment Agency. Between 2001 and 2007, such surveys were carried out at a total of 7,430 sites in England and Wales. The monitoring programme was reviewed in 2006, and the total number of sites to be sampled in future over each six year period has been reduced to 5,463, of which 1,115 sites are to be sampled annually. The majority of these annual sites (58%) are sampled quantitatively, while the remainder are sampled using a semi-quantitative method (i.e. one pass electric fishing as opposed to three or more passes).

These multi-species surveys are useful in examining the distribution of eel (presence/absence) and providing qualitative indices of relative abundance. However, an eel-specific focus is considered essential for robust local population estimates, since comparison between the results of multi-species and eel-specific surveys suggests the former may underestimate eel densities by a factor of 3 to 10 (Knights *et al*., 2001). Therefore, since 2001, quantitative sampling, where eel is the target species, has also been carried out at 25 sites across four rivers.

Appreciating the decline in eel stocks and the need for robust baseline data on eel populations, Defra initiated an extensive review of the status of eel and elver stocks on England and Wales in 2000, at a cost of ~£250,000. The study collated all the historic data on eel and reviewed current status for eel production in England and Wales (Knights *et al*., 2001). A second research programme (2002-2006: ~£238,000) developed a spatial-based life production model framework for UK eel (Aprahamian *et al*., 2007), and conducted comprehensive, eel-specific surveys of 14 basins in England and Wales (Bark *et al*., 2007; Bark, Knights and Williams, unpublished data). These data and associated analyses are described in the appropriate EMPs. They offer the opportunity to assess the status of at least some yellow eel stocks, and provide a possible means to extrapolate to silver eel escapement and hence assess production against the management targets. Cefas are conducting further development and tested of the model for the Environment Agency

(2007 to 2010: £211,000), with the aim of applying this model in basin assessments before the first reporting of the EMPs in 2012.

These survey data offer the opportunity to assess the status of at least some yellow eel stocks, and provide a possible means to extrapolate to silver eel escapement and hence assess production against the management targets.

1.3.3.2 Assessment of compliance with EC target

Article 2.5 of the regulation sets out three approaches to assessing compliance with the target. These are:

> *a) use of data collected in the most appropriate period prior to 1980, provided these are available in sufficient quantity and quality;*
> *(b) habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors;*
> *(c) with reference to the ecology and hydrography of similar river systems.*

Two approaches have been used in England and Wales for this phase of the EMPs; comparison with historical data (approach a) on RBDs where these are available, and a modelling assessment (combining approaches b and c); the Reference Condition Model (detailed in Appendix 3).

Historical comparison

There are few data in England and Wales on eel density or biomass prior to the start of the recruitment decline in 1983/84, or in the absence of anthropogenic impacts such as pollution, fishing or barriers to migration (summarised by Knights *et al.,* 2001). Where historic data are available then a comparison with current data has been made to assess compliance with the target. Though it is accepted that the assessment does not take into account the impact of anthropogenic influences, it does compare current eel densities with those derived from glass eel recruitment prior to the crash in 1983/84.

Modelling assessment

Only one site In England and Wales has a direct means of measuring silver eel escapement by numbers at least (via a resistivity counter on the River Leven, North West RBD). This means that the 40% target must be set, and compliance assessed, using a modelling approach. One possibility was to use the Reference Condition Model (RCM: Aprahamian et al., 2007; Appendix 3) to assess compliance for the RBDs in England and Wales and for the cross-border RBD with Scotland.

The RCM provides estimates of expected eel density in a river using simple empirical approaches. In many rivers of England and Wales, the density (numbers per m^2) of eel naturally declines with distance upstream from the estuary (Knights *et al.*, 2001; Ibbotson *et al.,* 2002). Data for 12 rivers surveyed in the 1970s and early 1980s have been used to create a model that predicts the yellow eel population (in terms of densities along the river) that would have been expected before the major decline in glass eel recruitment across Europe after 1983/84. Variation in this rate of decline between rivers was examined in relation to several basin-scale descriptors (gradient, discharge, area, presence of obstructions or lakes, and land-use types), and the mean gradient from source to estuary explained the greatest extent of the variation (Aprahamian *et al*. 2007). The model is

based on the assumption that the density of eel declines exponentially with increasing distance from the tidal limit, and therefore that we can assess yellow eel stock status by comparing the observed instantaneous rate of density decline with that expected according to the model relationship. In its basic form, the RCM assumes that the area of habitat available upstream of the tidal limit is uniform along the length of the river. However, it can be weighted according to the amount of habitat available to eel at various distances from the tidal limit.

The RCM provides a surrogate assessment of yellow eel production across the basin as a proportion of an historical, reference level of production derived from other selected rivers, but it does not provide estimates of the target or present-day levels of silver eel escapement. Therefore, and in the absence of robust data on the relationship between yellow and silver eel production for UK rivers, we assume a linear relationship.

The RCM uses density as opposed to biomass in the assessment of compliance. This can be viewed as precautionary as a decline in density appears to result in a shift towards a higher percentage of females in the population (reviewed by Davies and Jellyman, 2005). As females are larger than males the decline in density is not necessarily reflected in a decline in biomass and in some situations may increase (see South West RBD). If the decline in stock-wide glass eel recruitment continues such that it is insufficient to replace the number of emigrating silver eel then there will be an inevitable decline in biomass as the older (female) eel emigrate. The shift in sex ratio to the larger females effectively buffers the escapement biomass for a period but the river will become non-compliant over time. As a consequence, it will become increasingly difficult to achieve compliance until EU-wide measures effect a sustained increase in glass eel recruitment.

Estimates of current silver eel escapement can be estimated from yellow eel density and size frequency using a probability mode (A.Knights & M. Aprahamian, in prep.). Eel are sampled by electric fishing at a number of sites throughout the catchment. Estimates of population size are made from successive removals using Carle and Strub (1978). The probability that a yellow eel will mature into a silver eel was estimated using the relationship of Bevacqua et al., (2006):

$$Y(L_t) = Y_{max}\left[1 + e^{\lambda - L_t \eta - 1}\right] - 1$$

Where Y_{max} is the asymptotic maturation rate, λ is a semi-saturation constant and η is a shape parameter which is inversely proportional to the slope of the curve at $L_t = \lambda$. The semi-saturation constant (λ) was taken from data for the River Severn (643 mm for female and 364 mm for male).

The sex ratio of the population was estimated from density (# m^{-2}) according to the formulae of Bark et al.,(2007):

Percentage female = -73.7 × log *eel density* – 8.89

To convert density into biomass the mean weight of a silver eel was taken from data on the Severn and was 569g for female and 90g for male eel (Aprahamian 1988). Silver eel output for a particular river was estimated from the mean of the various sites.

Though it is possible to estimate silver eel output there are no estimates of silver eel production under pristine conditions available from rivers within England and Wales.

Estimates of silver eel production have been summarized by the EIFAC / ICES Eel working group in 2008 (ICES, 2008) and summarized in Table 1.

Country	River	Potential spawner escapement (kg/ha)	Reference
Norway	Imsa	2.27	ICES, 2008
N. Ireland	Bann	17.4	ICES, 2008
Denmark	Køge Lellinge Brede Bjornsholm	105 49 9 - 36	Rasmussen and Therkildsen, 1979 Nielsen, 1982 Bisgaard and Pedersen, 1990
Netherlands	Small water bodies and canals Lakes Coastal waters Flowing waters.	10-16 19-25 4 25.	Klein Breiteler (2008).
Ireland	Moy Garavogue Erne Corrib Burrishoole	5.3 5.4 4.5 3.4 0.9	ICES, 2008
France	Oir Fremur Loire	6.3 1.9 16.4	ICES, 2008

Table 1. Estimates of silver eel production.

Estimates of current silver eel escapement will be assessed for each RBD within England and Wales from yellow eel data, using an index river catchment to represent the entire River Basin. ICES advise that "….river systems with similar characteristics typically produce 25kg/ha of eel or more." It is presumed that this is based on data from the Netherlands and Denmark and is considered high when compared with data from Ireland and France and is certainly considered high in relation to the less productive, small spate rivers of the West coast. There are no historic data which can be used to verify a historic "pristine" production figure of 25 kg/ha. Comparison with some of the larger rivers notable the Loire, Bann, Moy, Erne and Corrib where production ranges from 3.4 kg/ha to 17.4 kg/ha would suggest a reference level of 20 kg/ha (and therefore a 40% compliance target of 8 kg/ha).

1.4 Fisheries management options to achieve compliance

The Regulation lists a number of possible options to increase silver eel escapement, but in the plans we focus on the potential across England and Wales for 1) a reduction in fishing pressure, 2) improving access and habitat quality, 3) reducing the impacts of entrainment, 4) controlling predators 5) restocking and 6) reducing the impact of pathogens and parasites. The use of these options varies between rivers and basins depending on local priorities. Some of these actions have already started and are outlined in the EMPs.

1.4.1 Reduction in fishing pressure

It is essential that exploitation is sustainable against the management target of 40% silver eel escapement, and it is important that the regulator (Environment Agency) works closely with the industry to ensure awareness of the eel issue. The information reported from the eel fishery in England and Wales is of poor quality and, although a new catch return system was imposed in 2005, many catch reports are still are not allocated to any particular river or RBD. The under-reporting of catches needs to be addressed and the quality of data improved. Work will be carried in the period 2009-2012 to improve the reporting system. The opportunity to achieve this may be resolved through the CITES Appendix II/Annex B listing for *Anguilla anguilla* coming into force on 13th March 2009.

Until more detailed information is gathered on stocks and the fishery to inform a better assessment of the impact of the eel fishery, the preferred approach to conserving a sustainable fishery while working towards achieving and maintaining compliance, should be to hold the fishery within its existing limits. This would be achieved by not allowing any increases in the number of instruments or the range of where they are currently operated. At present, the Environment Agency has the powers to bring in a byelaw to limit the fishery by reducing season length, but it cannot refuse a licence or restrict where fishers can and cannot fish within the existing boundaries. The Environment Agency is currently seeking powers in the Marine Bill to be able to limit the number of fishermen and will be examining byelaw options to reduce fishing pressure.

In July 2009 we started the process of bringing in new byelaws which will allow us to better regulate eel and elver fisheries (http://www.environment-agency.gov.uk/research/library/consultations/108465.aspx). Phase one, the consultation period, is between July 15th and September 7th following which the byelaws will be further developed and advertised in Autumn 2009. The proposed byelaws aim to address the inadequacies of our existing powers under the Salmon and Freshwater Fisheries Act 1975. The proposed new byelaws will allow us to:

- introduce an elver (glass eel) close season which will reduce exploitation by 50% and protect the end of the season where upstream migration is most crucial
- introduce a yellow and silver eel close season reducing fishing time by 30% and protecting the silver eel run (Proposed season would finish on September 1st)
- improve the quality of catch returns by not issuing a net fishing licence until we receive the previous year's catch return;
- limit the geographic extent of yellow and silver eel fisheries (i.e there is no expansion of the fishery);
- prevent net fishing for elvers at vulnerable locations;
- further specify eel and elver fishing methods and equipment;
- prohibit trawling for eel and elver.
- Limit the number of licences available to fish for eel (legislative powers are not yet in place therefore this will not commence until the 2011season, but statutory consultation will start in 2010))

We anticipate the byelaws will be introduced in early 2010, before the start of the next eel fishing season. These byelaws were drafted in response to the 2007 regulation. The 2008 and 2009 fishing seasons for elver were the lowest on record. We will also need to consider whether a closure of the UK eel fishery may be prudent. A decision would be

made after the current consultation process and feedback from all eel interests has been received.

Where the Environment Agency is the fisheries owner we have banned the netting of eel on our waters (see Anglian EMP). We also need to work with other organisations such as the Wildlife Trusts, River Trusts, Royal Society for the Protection of Birds and fishery owners to create reserves or sanctuary areas for eel, where there would be no fishing.

1.4.2 Improving access and habitat quality

The Environment Agency takes every opportunity to improve habitat and passage for fish (including eel) through its own internal work programme and its consenting of work by others. Also, as part of the programme to ensure the delivery of the objectives of the Water Framework Directive, the Environment Agency will ensure the needs of eel are embedded across its work programme and those of other organisations.

1.4.2.1 Physical barriers

As part of the Eel Management Strategy in England and Wales the Environment Agency identified the need for better information on identifying and removing the impact of physical barriers on eel populations and produced handbooks for practicing fishery managers on the use of fish passes for eel:

Solomon D J and Beach M H (2004). Fish pass design for eel and elver (*Anguilla anguilla*). R&D Technical Report W2-070/TR1. Environment Agency, Bristol, 92 pp, and

Solomon D J and Beach M H (2004). Manual for provision of upstream migration facilities for eel and elver (*Anguilla anguilla*). R&D Technical Report W2-070/TR2. Environment Agency, Bristol, 63pp

These reports present a detailed review of those aspects of the biology and life history of the eel that influence migratory behaviour. These include the seasonal timing of migration, the effects of water temperature, river discharge, light, tide, lunar cycle and time of day on migratory activity, climbing ability, dispersion and rate of upstream migration, vulnerability to predation, sizes of fish involved, and swimming ability. From this, a series of biological and non-biological design criteria were developed for upstream passage facilities for eels and elvers.

A similar approach is used to develop design criteria for the protection of downstream migrants.

Basic design guidelines are produced from a synthesis of the review of eel migratory behaviour and the analysis of existing eel passes. These include fundamental design considerations, siting of facilities, facilities based on substrates, facilities based on easements and “natural” channels, pipe passes, lifts and locks, upstream outlet arrangements, monitoring facilities, trap and transport, passage of eels through passes designed for other species, attraction flows, constraints at flow gauging structures, tidal barriers, maintenance and health and safety considerations, and protection of downstream migrants.

To further assist with improving eel upstream and downstream passage facilities a research programme with Southampton University commenced in 2008 (£98,000; € 118,000). The programme aims to study the behaviour of eel at obstructions and intakes to define mitigation, fish pass and environmental requirements of upstream (glass eel/elvers) and downstream (silver eels) migrating life stages. The objectives are to:

- To review existing information and links with existing projects
- To assess behavioural response of all life stages of eel to hydraulics and other environmental factors (e.g. light) to improve guidance efficiencies of eel passes
- To assess response of all life stages of eel to defined hydraulics at structural impediments
- To develop mitigation technologies for directing eels from hazards
- To determine optimal conditions at barriers and intakes for survival and migration of eels.

An annual programme of about £200,000 (€ 240,000) will be available in England and Wales for implementing measures described in the EMPs, much of which will be focused on improving access, details of which are included in the individual EMPs

An Environment Agency project in 2006 reviewed numerous riverine obstructions across England and Wales and subjectively assessed the passability of each structure by eel. From this work maps have been produced (in each EMP) to indicate the degree of free passage within each RBD. In general, however information on the distribution of all obstructions in England and Wales and their passability for eel is poor and further work is required to enable a more comprehensive assessment of all barriers specifically with respect to eel migration. The aim over the next three years (before the 2012 reporting round) is to assess the passability for eel at obstructions across England and Wales develop a plan of priority actions for improving eel passage within each RBD. As with habitat assessments in general, there are limited mapping data available with which to quantify the effects of improving eel passage at the obstacles, but these data will be collected and GIS analyses developed as part of these plans.

Figure 6. Tidal flap gate on the Severn.

There is perceived to have been a loss of habitat over the last half-century, particularly in the lower reaches of river basins, which may have resulted in a reduction in eel production as a result of the construction of tidal flap gates on land drainage schemes (Figure 6). New and novel designs may be needed to improve access to these areas and it will be important to liaise closely with the Living North Sea Interreg project, as it aims to improve connectivity in these types of habitat.

To address this around £750,000 has been made available for delivery of actions outlined for 2009/10. We are proposing to install in the region of 120-140 eel passes in 2009/10 (Figure 7). These will consist of low cost solutions to traditional weir type obstructions (Figures 8 and 9) to improving tidal connectivity through modification of tidal flaps (Figure 10). Priority is being given to those structures in the lower reaches and to those which will improve access to the most amount of habitat.

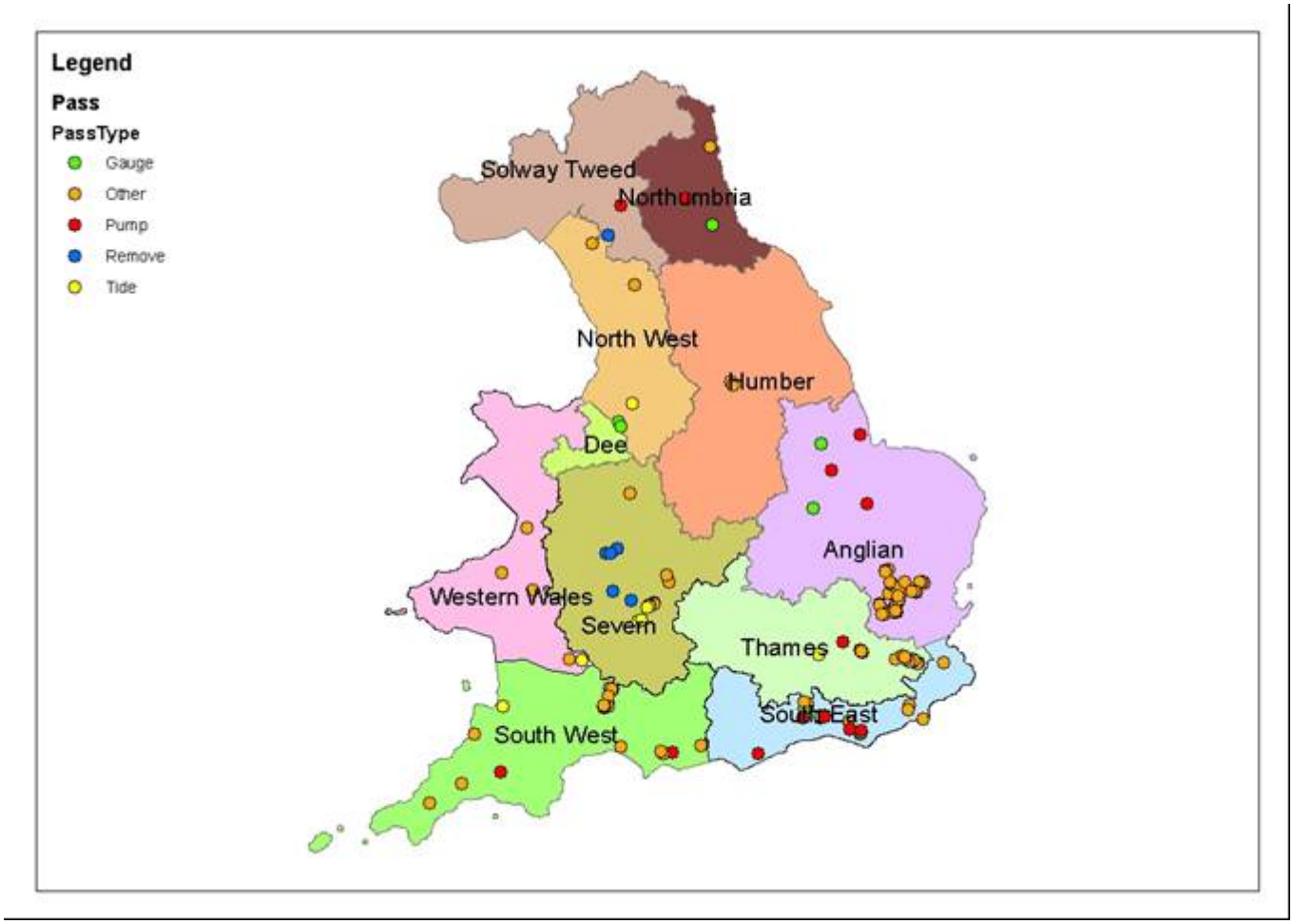

Figure 7. **Location of fish passes to be installed or where weir removals are to be undertaken in 2009/2010.**

Figure 8. **Bristle board eel pass**

Figure 9. Bristle pass designed for a tilting weir

Figure 10. Tidal flap gate

1.4.2.2 Water quality and chemical barriers

The Environment Agency measures water quality in England and Wales using the General Quality Assessment (GQA) system, which assesses stretches of freshwater in terms of their chemical, biological and nutrient levels (Figure 7 a & b). Some RBDs have been impacted by eutrophication (Figure 8 a & b), but nutrient loading from point sources such as industry and sewage treatment works has been greatly reduced in the last 20 years. Pollution is still an issue, and persistent chemicals from a range of sources are known to impact on fish stocks (Foster and Block, 2006). The Environment Agency will continue with on-going programmes needed to achieve better river quality and good ecological status to meet the objective of the Water Framework Directive. These will include:

- contributing to more environmentally-sensitive land-use practices, and particularly those relating to agriculture,
- influencing the programmes of investment in the sewerage and water supply systems operated by the water companies;
- promoting environmentally-sensitive management of water resources;

- incorporating environmental improvement into plans to manage flood risk;

Although not targeted specifically at increasing eel production, these measures will contribute indirectly.

1.4.2.3 Contaminants

One water quality issue that may have an impact on eel stocks, but not presently assessed by the GQA, is the presence of contaminants. Eels contain a high level of fat in their muscles and, as a result, readily accumulate fat-soluble chemicals such as organochlorines. Recent research reviewed by ICES (2006) shows that the quality of the silver eels escaping from the continent might be seriously impaired in this way. Subsequently, ICES (2007) collated contaminant level data for eels across Europe. It noted current gonadal levels of dioxin-like contaminants, including PCBs, in eels from most European locations exceed those shown to impair embryonic development in R&D studies (EELREP, 2005a, 2005b; Palstra *et al.* 2006); that the emission of PCBs into the environment preceded the recent decline of the European stock; and that PCBs and DDTs had a negative impact on the lipid levels in eels. The review concluded that contamination with PCBs and other pollutants may have contributed to the decline of eel recruitment observed since 1980. However, there is no means, at present, to quantify the potential impact of such contaminants on silver eel production.

There are no national field sampling programmes that address this issue in England and Wales. However, a workshop was held in November 2008 to 1) discuss which were the priority contaminants to measure, 2) identify the high risk areas and 3) prepare proposals for monitoring and research which will "i*ndicate the degree of contamination infection in each EMU"* as highlighted in the guidelines. Furthermore, the EIFAC/ICES WGEEL are expected to continue to provide updates on this topic on an annual basis, and the UK will continue to contribute to this review, and incorporate new information in assessments.

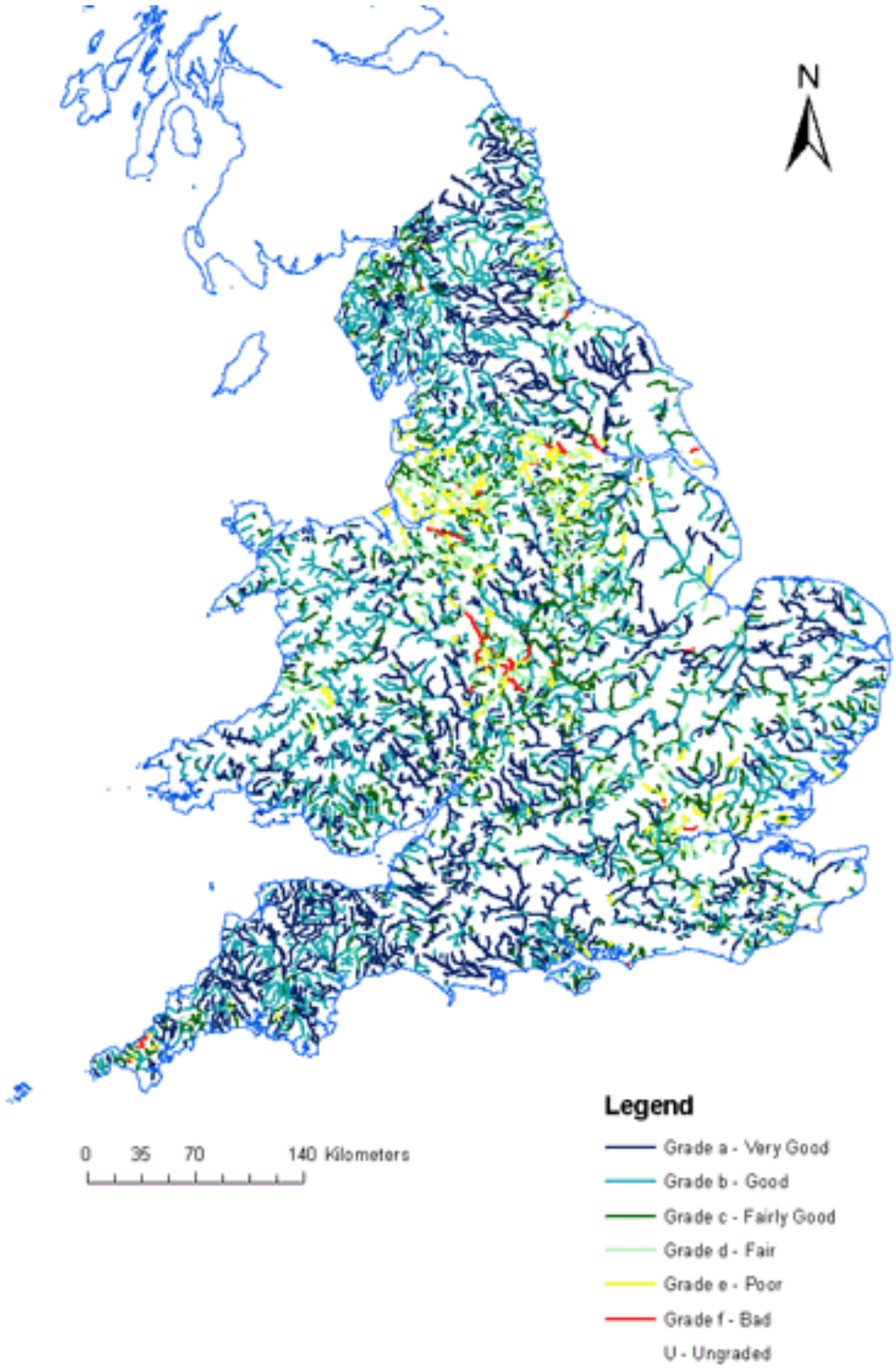

Figure 7a. General Quality Assessment for biology.

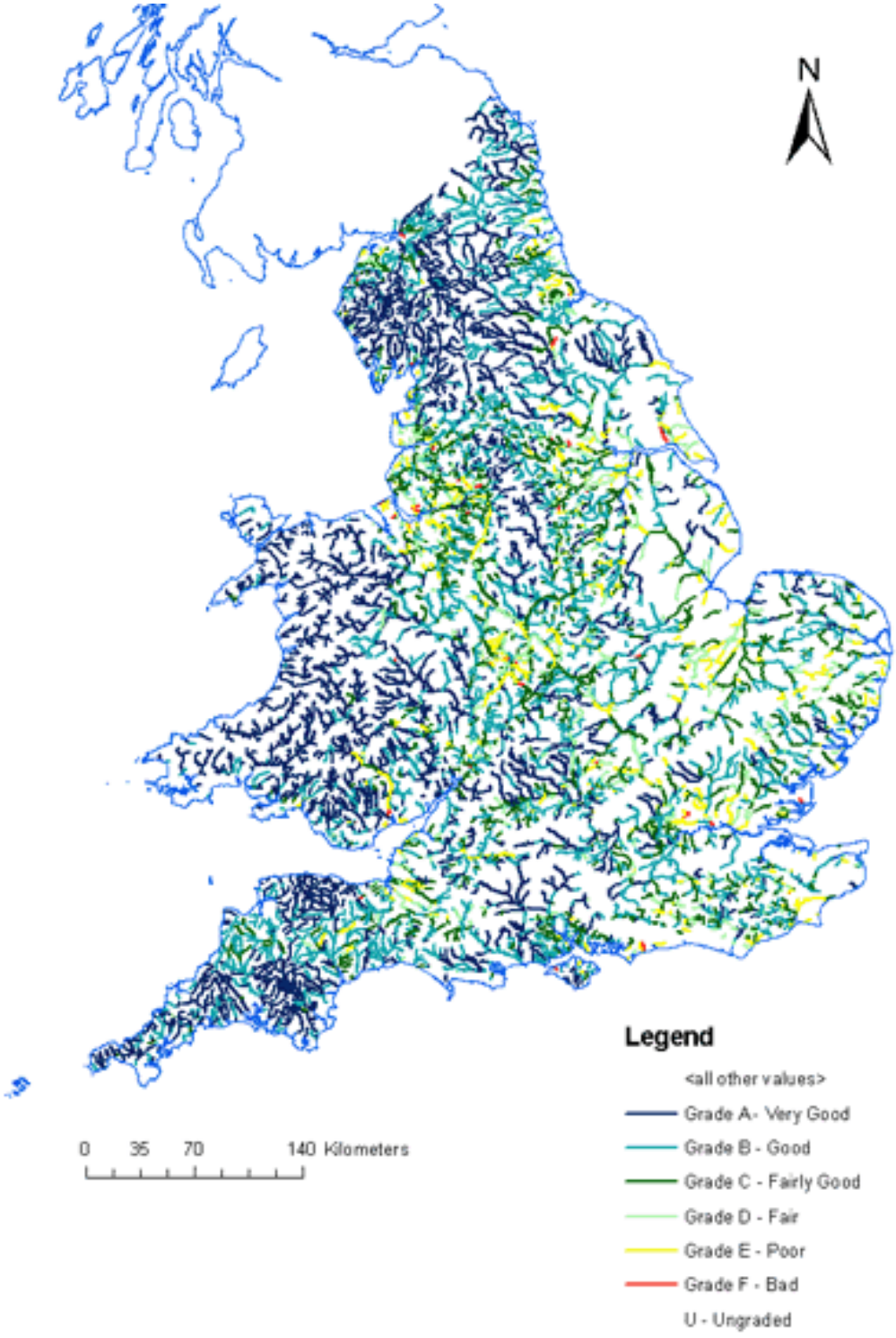

Figure 7b. General Quality Assessment for water quality.

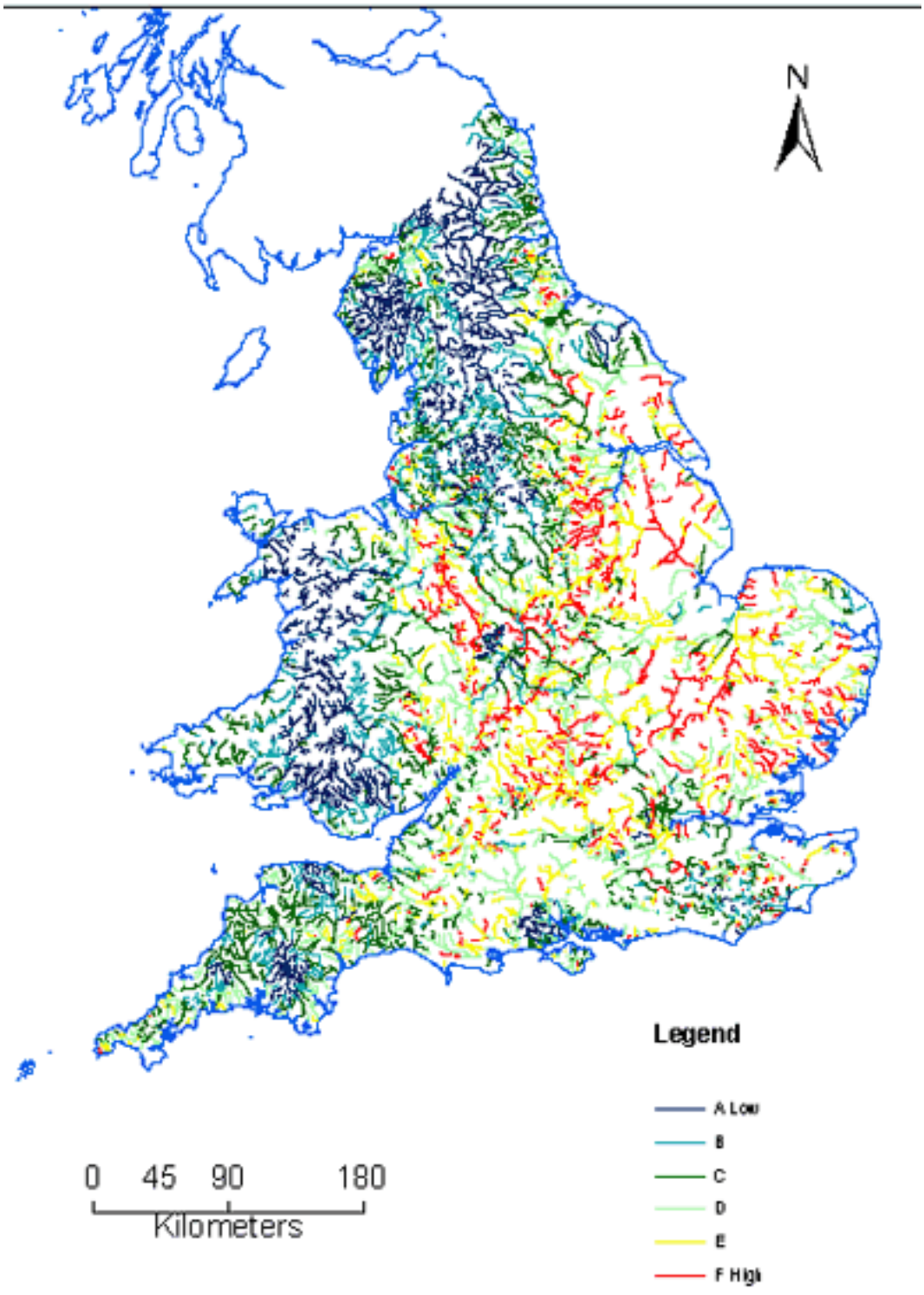

Figure 8a. General Quality Assessment for nitrate.

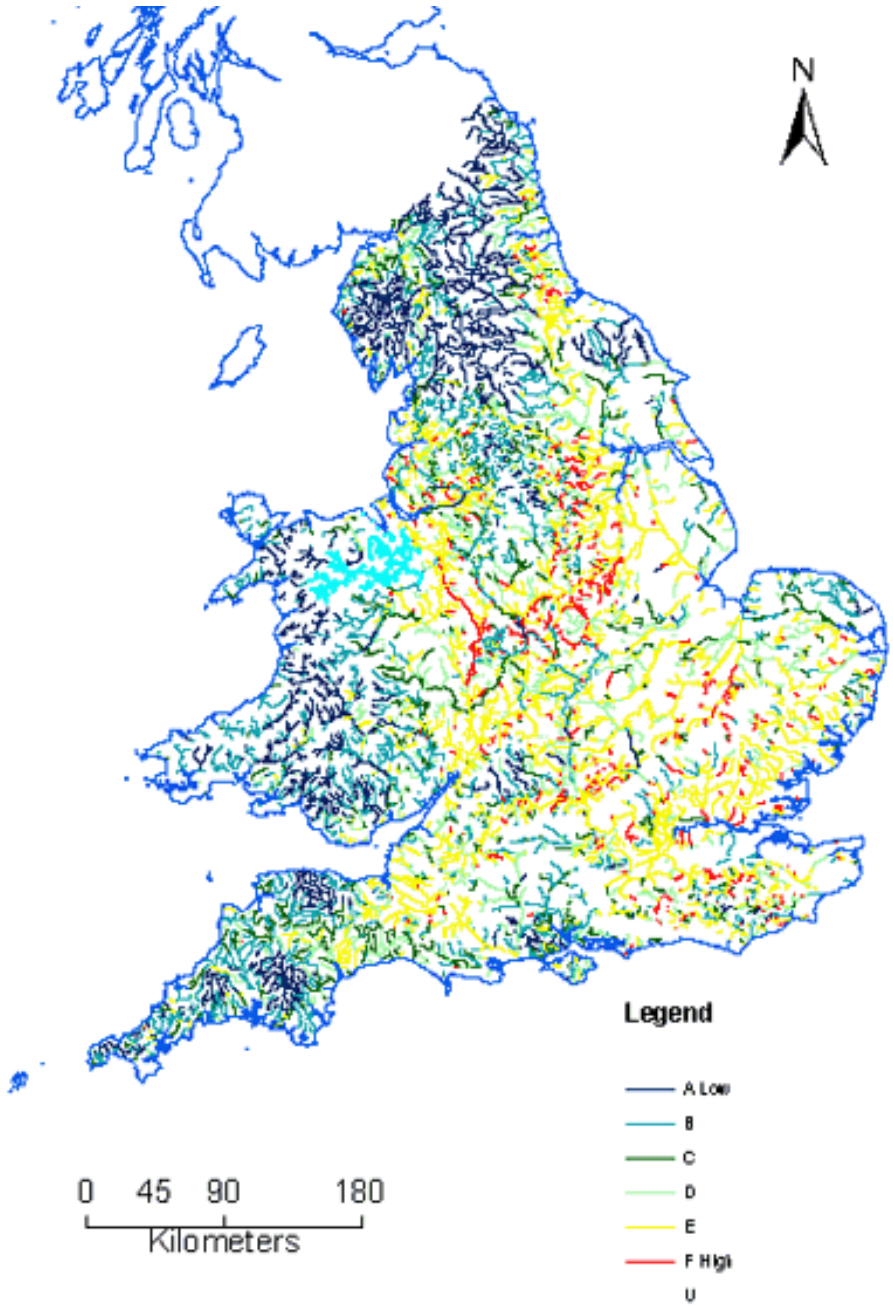

Figure 8b. General Quality Assessment for phosphate.

1.4.3 Reducing the impacts of entrainment

Entrainment and impingement of eel at abstraction points, cooling water intakes and tidal power plants can be a major cause of mortality in some rivers. Although yellow, silver and glass eels have been recorded at many water intakes in England and Wales, there has been no concerted effort to quantify the impact of entrainment on stocks at a Regional or National level (Environment Agency R&D report, 2005). In recent years, there has been increasing interest in low head hydropower on rivers in England and Wales. The EIFAC/ICES Working Group on Eels reviewed the available evidence on eel mortality during downstream migration in 2007 (ICES, 2007) and found that eels have considerably higher mortality rates at hydropower stations than other fish: injury rates from turbines ranging between 15 and 38%. On rivers with a number of major barriers, and the potential

for several hydropower plants to be installed on consecutive weirs, consideration must also be given to cumulative mortality.

The Environment Agency has produced a handbook for screening at water intakes:

Turnpenny, A. W. H. and O'Keefe, N. (2004). Best practice guide for intake and outfall screening. R&D Technical Report W6-103. Environment Agency, Bristol, 139pp

The guide updates a previous review (NRA R & D Technical Report No. 1, 1992) and provides a description of the legal responsibilities of operators of water intakes and outfalls. A review of the wide range of technologies that are in common use for fish screening is provided, including physical and behavioural screening technologies. The review will guide users towards current best practice to assist in the task of screen selection and specification.

Other solutions need to be considered and include the possibility of more fish-friendly pumps such as the Manshanden Fish Way where a Venturi pump is installed in addition to conventional pumps. The design provides an obstacle free connection between upstream and downstream waters, but costs in the region of €160,000. This is especially relevant in those low lying areas around the Humber (Humber EMP), the East Anglian fen drains (Anglian EMP) and Somerset levels (South West EMP). At hydropower sites, consideration will need to be given to using "fish friendly" turbines, where the leading edge of the blades have been blunted to reduce mortality, but further development in this area is needed.

Although little information exists at present, the aim by the next reporting round in 2012 is to identify where significant sources of mortality due to entrainment may exist, to propose how these might be reduced, and have begun to implement such reductions. The current knowledge of the impact of entrainment and hydropower in each RBD is presented in the individual EMPs.

1.4.4 Controlling predators

Cormorants (*Phalacrocorax* spp.) are considered to be among the most abundant avian predators of eel, at the pan-European level (ICES, 2007). Though data are sparse for cormorant predation on eel in England and Wales (and throughout the UK) an estimate of the number of eel eaten by cormorants is made using data published in the literature (see ICES, 2007; Appendix 6). Grey herons (*Ardea cinerea*) take eels, but generally in the size range 16-30 cm in length (ICES, 2007). Predation by sawbill ducks (*Mergus* spp) on eel is generally of the smaller individuals than those consumed by cormorants: diet varies seasonally and spatially; between and within catchments and years. Other fish-eating birds (e.g. osprey *Pandion haleatus*) are recorded taking eels on occasion but the fish is not a common prey item.

Otter (*Lutra lutra*), and mink (*Mustela* spp.) also take eel. Although there is no available information on the likely levels of predation, Miranda *et. al.*, (2008) found that otter diet was dominated by eel in the Somerset Levels, (28% of the food biomass annually and 56% in the autumn). Despite this preference, populations of these mammals are much lower than those of fish-eating birds and they are likely to contribute a very small proportion of eel mortality.

Piscivorous birds in the UK are protected under the Wildlife and Countryside Act 1981, which implements the EC Birds Directive (79/409) and which protects all wild birds, their eggs and nests. However, there are provisions enabling birds to be shot (and killed), under licence, for the purpose of preventing serious damage to fisheries. No licence is required for non-lethal shooting to scare.

Applicants have to satisfy a number of criteria before a licence is issued. For example, licences are issued where:

- birds are causing, or are likely to cause serious damage to fish stocks or fisheries;
- other, non-lethal, anti-predation measures have been tried and found to be ineffective, or the methods are impracticable at the site;
- other factors are not likely to be responsible for the serious damage;
- shooting will help to prevent damage; and
- there is no other satisfactory solution.

The European subspecies of the otter is listed as “globally threatened” on the IUCN/WCMC Red Data list. It is also listed on Appendix I of CITES, Appendix II of the Bern Convention, and Annexes II and IV of the Habitats Directive (92/43/EEC).

The EMPs will attempt to quantify the impact of cormorants in terms of the quantity of eel eaten. It has not been possible to estimate the losses from other piscivorous birds and from otter or, mink. However, under current legislation the killing of fish eating birds or otters to reduce their predation on eel numbers is not an option. Therefore there are no proposals within the EMPs to combat predators in England and Wales.

1.4.5 Restocking

The Regulation requires that at least 35% of the commercial catch of eels of less than 120 mm is made available for restocking in 2009, rising to 60% by 2013. If this full quota were to be taken up it would represent the largest and most extensive fish restocking exercise ever carried out in England and Wales. Clearly, it is of paramount importance that such a stocking programme would be conducted in a manner which maximises effectiveness, optimises resources and minimises risk. There is a general assumption that stocking increases the overall production of eel in a river system that is currently not fulfilling its potential. It is believed that this is due to increased growth rate and lower mortality of eels stocked into more productive but naturally under stocked areas. There is evidence from the Severn that glass eel stocked in the middle reaches did grow substantially faster than those in the lower reaches (Aprahamian, 1987). However, the main issue regarding the stocking of eel in England and Wales is the purchase cost, which was in the region of £400 per kilogram in 2008.

Although a number of reports have considered approaches and techniques of stocking juvenile eels (e.g. Knights and Higgs, 1988, Knights and White 1998, Williams and Aprahamian, 2004), these appear to approach the subject with the aim of achieving optimal levels of stock in the receiving waters from a viewpoint of exploitation. Now that species conservation is the driver, the issues are rather different, and no study appears to have addressed this from first principles. The ICES/EIFAC WG on Eels has been exploring this issue for some years, and their 2007 report recommended that “guidelines, or best practice manuals, should be established for methodologies for….stocking of eel”.

As such, stocking plans will be developed for each RBD in England and Wales and for that part of the Solway Tweed RBD that is under English jurisdiction within the first year of approval of the EMP (i.e. during 2009/10) since the first glass eel fishing season to come under the new regulation will be 2010. Priority will be given to those RBDs which are failing the escapement target. To facilitate this, two projects are currently under way which should report by the end of March 2009. These are:

1. Developing guidelines for best practice in stocking eel for enhancement purposes, being conducted by Cefas. The objective is to develop an Eel Stocking Assessment Tool (ESAT) to support rapid decision making for stocking events. The quantitative model will incorporate eel production processes of growth, mortality, sex differentiation and maturation, applied from the glass eel/elver to silver eel stages. The tool will then be incorporated within an updated review of 'best practice' guidelines to provide a comprehensive package of tools for eel managers based on our most up-to-date knowledge. This will not cover the impacts on production of such issues as parasites, diseases, pollution, etc, but the model will be able to accommodate putative changes in survival due to these factors.

2. The development of a guidance note on redistribution of juvenile eels for conservation purposes, being undertaken by D. Solomon. Areas that will be addressed include: -

- General assessment of the waterways appropriate for receiving redistributed stock in England and Wales, including estimates of area.
- Consideration of the optimal density, frequency, timing and tactics of stocking given the conservation aim of the practice (taking full account of experience elsewhere).
- The numbers of juvenile eels that might be involved in a redistribution programme.
- Sources of young eels.
- Practical disease and parasite safeguards and requirements (taking full account of current Environment Agency policies).
- Elver transport techniques and practices.
- Assessment of the cost and manpower implications.
- Monitoring protocols to assess the effectiveness of stocking and to allow adjustment of programmes.
- Proposals for pilot-scale programmes to trial the guidance in 2009.
- Other issues including effects on genetic and sex ratios.

It is also proposed to contribute to the second phase of INDICANG. INDICANG 2 is an INTERREG (Atlantic Arc) project building on the outputs from INDICANG 1. INDICANG 1 developed indicators of stock status for glass, yellow and silver eel stages, and habitat quality. The UK involvement in Indicang 2 will focus on testing those tools that will be needed to support the post-evaluation of Eel Management Plans. One objective is to evaluate the efficacy of stocking eel to increase net silver eel output and thus contribute to the Eel Recovery Plan. It will focus on the following issues:

- Ideal age group to be stocked: is there any advantage in growing on glass eel and stocking at a later stage?
- Where and when (timing) stocking should be undertaken,
- Frequency of stocking
- Density of stocking in relation to carrying capacity of habitats and sex ratio of output (silver eel)

- Net benefit of stocking over the “do-nothing” option and how this relates to the Management Target.

The Indicang 2 proposal will be submitted in spring 2009 and, if successful, will begin in autumn 2009.

Though stocking plans will be produced for each EMP as required by the Regulation, England and Wales is not relying on stocking to meet the escapement target if the RBD is failing for the following reasons:

- There is concern on the amount of stocking material, in 2009 approximately 250kg was available and all of this has gone to stocking mainly to N. Ireland and Sweden. If the 2009 season is representative of future catches, then there will be a significant shortfall for restocking to be the primary means to achieve 40% escapement.

- Restocking is not seen as the most sustainable action when compared with improving access. The cost of an eel pass is in the region of £800 equivalent to stocking 4 kg (12 000) glass eel. Where we have installed passes we have recorded thousands of eel moving pass these structures in the first year. We consider this to be the most sustainable management option to engage in.

- England and Wales is not keen to use material caught other than by dip-nets as this achieves the best quality product. Elvers acquired from fisheries that use trawls or large boat assisted seine nets suffer very high mortalities. UK elvers are hand caught and of premium quality.

1.4.6 Pathogens and Parasites

The main parasite of concern for silver eel production is *Anguillicoloides (Anguillicola) crassus.* This is a parasitic nematode worm found throughout East Asia in its native host the Japanese eel (*Anguilla japonica*), but has been discovered to infect the European eel (*Anguilla anguilla*) and more recently, the American eel (*Anguilla rostrata*). Its range has subsequently spread into the continents of Africa, Europe and America. In Europe it is thought to have first been introduced in the early 1980’s via the live import of Japanese eels for the food trade (Kirk, 2000).

A. crassus spends a period of its multi-stage life cycle inside the swim bladder of the eel, where it attaches to blood vessels. Swimming trials in flumes suggest that infestation of the parasite reduces the migratory capacity of silver eels (ICES, 2007). Investigations have shown that eels infected with 10 nematodes had a swimming speed 18.6% slower than uninfected eels (Sprengel & Lüchtenberg 1991). Mass mortalities of both farmed and wild populations of European eels have resulted from *A. crassus* infestations (Kirk, 2000).

The parasite is now considered ubiquitous throughout England and Wales, and any gaps in its known occurrence probably reflect incomplete investigation rather than true absence (Hewlett, N., Environment Agency, pers. comm.). There is, however, little quantitative evidence on the prevalence or on the intensity of infection in the UK, by life stage. Any local data are presented in each EMP.

Viral infections such as the rhabdovirus EVEX (Eel Virus European X) and *Herpesvirus anguillae*, reported in wild and/or farmed eels around the world also represent a potentially serious threat to European eel stocks. Again, flume trials suggest that the EVEX virus reduces the migratory capacity of infected silver eels. Infected eels subjected to simulated migration to the Sargasso Sea developed haemorrhages and anaemia, and died after 1000-1500 km, well short of the distance required to reach the Sargasso Sea (Ginneken *et. al*., 2005).

A workshop was held in November 2008 to discuss possible impacts on eel health, including pathogens, parasites and contaminants, and to develop proposals for research and monitoring which will "*indicate the proportion of eel of each life stage affected by pathogens and parasites"* and *"Indicate the degree of .... parasitic infection in each EMU"*, as highlighted in the guidelines. The proposal will then be submitted to funding organisations. These data will be used to help with risk management, for example when considering the stocking of juvenile eel and when improving habitat available to eel.

1.4.7 Time schedule for attainment of escapement target level.

Åström and Dekker (2007) provide the first estimate of the time it may take to restore the spawning stock to a level that does not impair glass eel production. They conclude:

- "the eel being slow-growing, recovering the stock will take considerable time, of the order of several decades, even after massive reductions in mortality;
- the length of the recovery period is tightly linked to the level of reduction in fishing (or other anthropogenic) mortality;
- large reductions in mortality are required to achieve long-term recovery;
- an initial increase in recruitment does not guarantee long-term recovery."

For these EMPs an estimate is made of the time to meet compliance for those river basins that are currently failing. At the moment compliance with the 40% escapement target has been assessed using the Reference Condition Model and information from eel specific surveys of yellow eel populations in 2005.

HMRC import-export records of glass eels from 1982 to 2008 suggest that eel recruitment has declined by around two percent each year. Assuming that yellow eel density is directly proportional to glass eel recruitment then yellow eel densities, and silver eel escapement, have declined by a similar proportion each year and will continue to do so until actions to improve populations are initiated.

After any actions are begun there will be a lag before escapement increases of around 10 to 20 years whilst yellow eels mature. The population should then increase in proportion to the actions that are taken. In the timelines presented in the EMPs, the time lag is assumed to be 15 years and the actions carried out each year are assumed to increase yellow eel populations by 0.5 percent of pre-1980s levels. These actions could include increasing accessible habitat, stocking, or reducing the mortality of yellow and silver eels. The precise nature of these actions will be taken on an individual river basin basis.

1.5 Resources available for management measures

In addition to the centrally funded resources already mentioned, the Environment Agency applies considerably greater levels of funding to work to protect and improve the water

environment. In 2006/07 £119 million, from charges and Government grant, was spent on water quality protection and £125 million from abstraction charges funded the management of water resources. There are constraints on how these funds may be spent but the Environment Agency seeks to ensure that the funds are deployed to the benefit the whole water environment.

The governments of England and Wales, working with other agencies, control substantial funds directed towards agriculture and land management. The water companies apply major sums to benefit the environment within their investment programmes. How these resources are used and directed can have significant influence on the environment and benefit eel.

Many other organisations and individuals work, and invest significant resources to protect and improve the environment and though partnership a range of other funding sources can be exploited. The Environment Agency want to underpin the delivery of the objectives of the EMPs by ensuring that all available resources are deployed to maximum benefit, by encouraging increased investment and by ensuring that the strong case for public funding is understood**.**

Application will be made to the European Fisheries Fund (EFF) to support the Eel Recovery Plan in England and Wales. Applications will be made under Axis 3 - Application for a Grant for "Measures of common interest" to protect and develop aquatic flora and fauna. There is a limit of £100,000 per application. The grant must be matched equally by money from other national sources or private investment. In Cornwall (part of the South West RBD), the EFF grant may be as much as 75% of the total project costs when the application is made by a public body. For all other areas of England match funding is up to 50%.

1.6 Future developments

In addition to those items identified above there are four areas of activity which will assist with the Eel Recovery Programme.

1. improved model(s) to assess compliance with target and benefits of management actions,
2. increased monitoring to improve the accuracy of the assessments and
3. additional legislation which will enable the Environment Agency to better regulate eel fisheries and to improve access for eel
4. Developing stakeholder involvement

These four areas are considered in more detail in the following sections.

1.6.1 Model(s) to monitor compliance and management actions

The simplicity of the RCM model makes it relatively easy to use but also limits the potential of this approach. The model is based on a limited dataset of rivers, mainly from southwest England, which are relatively short and rise steeply up to low-productivity moorlands. Further development of this approach requires more data from a variety of river types covering a wider geographical area, especially east coast lowland systems with relatively low recruitment, and those with on-line lakes. It is also important to examine a wider suite of explanatory variables, particularly other catchment and water quality variables.

While the RCM is the most practical model to apply in the early development of English and Welsh EMPs, its utility in the long term is limited because of the above issues, and because it is based on eel densities rather than biomass, of yellow eel rather than silver eel production, and because it cannot be used to simulate the effects of management measures or assess their relative contributions to population enhancement.

To address the limitations of the RCM model a spatial, life-history model, the Scenario-based Management of Eel Populations, (SMEP) [Aprahamian *et al*., 2007] is currently under development. It is a much more complex model than RCM, including features that are not often included in population dynamics models applied to many other species (e.g. density-dependence at older ages, spatially disaggregated simulation of dynamics), all of which, however, might be of importance in the description of an eel's life cycle. It is applied at a basin scale, and can incorporate both the biological characteristics of eel production (e.g. growth, natural mortality, sexual differentiation, maturation, migration) and a number of potential anthropogenic influences (e.g. habitat quality, fishing, barriers, stocking). The increase in realism in the simulation of population dynamics that SMEP offers does come at a cost in terms of high data requirements, increased uncertainty (though better quantified) and the need to translate knowledge into quantitative formulae.

SMEP has the potential to provide a comprehensive tool for managers to use in the further development and implementation of EMPs. Given an appropriate set of parameters to describe the production of eels in a specific river basin, and an accurate description of the eel-producing habitat, the SMEP approach should provide an estimate of compliance with the target for silver eel escapement. It is proposed that compliance will be assessed in the 2012 reporting round using the SMEP.

For the current set of EMPs a very tentative assessment as to when compliance might be reached is presented. For the next reporting round SMEP will be used to produce a better assessment of when the escapement objective will be attained.

In addition to developing and testing SMEP, the UK will continue to monitor developments in other modelling approaches, and will consider application of such other models, as and when appropriate.

1.6.2 Monitoring

The amount of eel specific monitoring will increase from 2009 onwards.

Yellow eel monitoring as part of the Nationa; Fisheries Monitoring Programme (NFMP) previously covered 3 rivers, this has now been increased to 22 rivers (Figure 9). A minimum of 10 sites on each river are monitored biennially. The sampling method of choice is quantitative electric fishing with fyke netting being used in rivers unsuitable for electric fishing. Glass eel/elver and silver eel monitoring was being carried out in some areas but we have now focussed our monitoring effort on the most appropriate sites. Glass eel/elver are monitored annually at three sites using traps on fixed structures. Silver eel are monitored annually at five sites using a combination of existing silver eel traps, fyke netting and acoustic monitoring (DIDSON).

In addition to the eel specific surveys we carry out over 3000 fisheries surveys annually, all eel caught on these surveys are measured and recorded. We are looking at the methods we use on these non eel specific surveys to see if we can improve the eel data we collect

for example by adding additional runs targeting eels to our multi species catch depletion surveys.

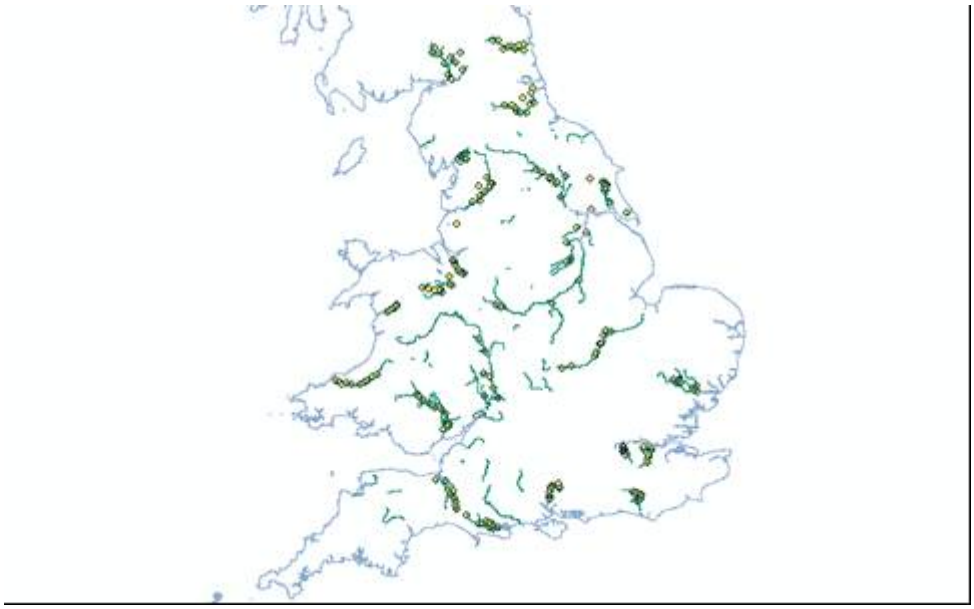

Figure 9. **Location of eel index river sites.**

The Environment Agency's eel monitoring programme will be reviewed once the findings of the first phase of INDICANG have been reported. This is to ensure that the programme represents best practice and meets the data requirements of the models (SMEP) being developed.

In addition to the extra level of eel specific monitoring, further work is on-going to improve our use of multi-species survey data. Interpretation of the eel component from the routine multi-species electric fishing surveys is presently under development and relationships between eel population data and environmental data are being explored. The aim is to compare the observed density with an expected density derived (at present) from river width, altitude and a spatial component based on rivers that have no anthropogenic impacts on eel populations. The spatial component is to take into account the fact that populations on the east coast are further away from the main recruitment pathways when compared to the west coast and thus naturally have a lower density (Knights *et al*., 2001). The expected abundance effectively reflects habitat suitability of the particular stretch of river where surveys were conducted. The Environmental Quality Ratio (EQR) [i.e. the observed density in relation to the expected density], for each site can then be determined and used as an index of stock status. It is also hoped that this will form a component of INDICANG 2.

1.6.3 Legislative changes

In 2004, a national set of eel byelaws came into force in England and Wales (see Appendix 2). This standardised the previous local byelaws applying to the commercial eel fisheries. The existing powers under the Salmon and Freshwater Fisheries Act 1975 are inadequate to deliver many of the other measures that are considered necessary to comply with the EU Eel Regulation.

The Eel Regulation will come into force in July 2009. The first full fishing season to come under the new regulation will be in 2010. The regulation will require The Environment Agency to put new rules into place but, as things stand, many of these cannot be formally proposed and consulted upon until the Marine Bill has been passed with royal assent. As this is unlikely to happen before Autumn 2009, we will have limited time to process new regulations with appropriate consultations in time for the 2010 season.

To “bridge” the gap until other measures can be in place a Statutory Instrument (SI) is to be implemented using existing powers under the European Communities Act (the measures being to uphold an EU Regulation). We are currently in discussion with Department of the Environment, Food and Rural Affairs (Defra) and Welsh Assembly Government (WAG) to agree the form and content for this SI. The SI is designed to allow the Environment Agency to meet its obligations under Article 5 and 7 with commencement in October 2009.

Article 5: The SI should empower the Agency to be able to close fisheries for yellow / silver eels from 15th August to 31st December 2009. This will reduce the fishing season by half and thereby reducing fishing effort by 50%.

Article 7: The SI should require all registered and authorised elver stations to ensure that a percentage, as stipulated by the Agency, of their stock of eels less than 12cm in length should be offered and /or sold for restocking purposes.

The Convention on International Trade in Endangered Species (CITES) is also reviewing requirements for eel. Trade in eel will be more closely regulated. The possibility of a ban on the export of eel outside the EU is under serious consideration. CITES restrictions are likely to require further regulatory developments in England and Wales, for example relating to the recording of catches and sales.

We expect that the developments needed to protect eel will be covered by different legislative routes, these are detailed in Appendix 12.

1.6.4 EMP Implementation groups

The Environment Agency, as the body responsible for delivering the Eel Recovery Plan in England and Wales recognises that it cannot do this alone; as its resources are limited and, in many instances, others are better placed to deliver on behalf of the environment.

There is a need and a desire to work with others to promote eel conservation and increase silver eel production. The most effective use of resources can be made by working to the strengths of partners and to this end EMP implementation groups will be set up to deliver the objectives of the EMPs. As part of this increased emphasis on a partnership approach the Environment Agency will need to encourage openness and transparency and must ensure that those involved are kept well informed.

2. Layout and structure of the plans

The content of each EMP is set out below and has been designed to follow the guidelines for completion of EMPs.

1. **Introduction**

2. **Description of the River Basin District**
   - 2.1 The River Basin District
   - 2.2 Current eel population
   - 2.3 The Fishery
   - 2.4 Silver eel escapement
   - 2.5 Eel mortality and available habitat

3. **Restocking**
   - 3.1 Habitat to be restocked
   - 3.2 Past restocking
   - 3.3 Potential restocking in the RBD
   - 3.4 Eels to be restocked in 2009
   - 3.5 Compliance with restocking requirements in the Regulation

4. **Monitoring**
   - 4.1 Assessment of silver eel escapement
   - 4.2 Price Monitoring and reporting system
   - 4.3 Catch and effort sampling system
   - 4.4 Traceability of live imported and exported eels

5. **Measures**
   - 5.1 Measures to meet Escapement Objective
   - 5.2 Measures taken 2007 to 2009
   - 5.3 Measures to be taken 2009 to 2012
   - 5.4 Measures to be taken beyond 2012 to achieve Escapement Objective

6. **Control and Enforcement**
7. **Modification of Eel Management Plans**

To support the EMPs and to avoid repetition a number of appendices have been included. These deal with:

Appendix 1 – Organisation structure within England and Wales
Appendix 2 – Legislation relating to eel Fisheries.
Appendix 3 – Reference Condition Model
Appendix 4 – Estimation of catch by recreational fishermen
Appendix 5 – Estimation of impact from entrainment including hydropower
Appendix 6 – Estimation of quantity of eel eaten by cormorants
Appendix 7 – Estimation of stocking requirement and guidelines for stocking
Appendix 8 – Method of price monitoring
Appendix 9 – Catch and effort sampling system
Appendix 10 – Monitoring origin and traceability of eel
Appendix 11 – Sampling system for catches and effort concerning all life stages of eel, with regard to Regulation (EC) no. 1639/2001.
Appendix 12 – Control and enforcement

Appendix 13 – Information concerning fishing activities