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# Recent recruitment trends of juvenile eels in tributaries of the River Thames

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**Abstract** Over the past 25 years it has become apparent that European eel recruitment has declined despite increased awareness and the development of protective legislation at local, national and European levels. A number of factors in both the freshwater and marine environment have been identified as potentially causing the decline, but there is little evidence how they specifically affect eel populations. There has been very little monitoring of European eel populations and therefore few robust data sets to allow long-term analysis. Eels were monitored at three sites in the Thames catchment between 2005 and 2009. At one site (River Roding) the catch per unit effort declined significantly after 2007, whilst at the other sites (River Thames and River Darent) catches were low throughout the period of the survey. Comparison of eel abundances at the River Darent caught in the present study with those caught in the mid 1980s would indicate that recruitment has declined by over 99%. The study highlights the lack of data relating to eel recruitment in the River Thames, and the UK as a whole, and supports both improved monitoring and the adoption of a precautionary approach in their management, irrespective of the causal factors for the decline.

**Keywords** *Anguilla anguilla* · Recruitment decline · Migration · Thames Estuary

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## Introduction

In the past 25 years there has been growing concern in relation to the decline in recruitment 'outside its safe biological limits' of the European eel (*Anguilla anguilla*) across Europe (Dekker, 2003; ICES, 2008). *Angullia anguilla* is listed as 'Critically Endangered' on the IUCN Red List of Threatened Species (IUCN, 2009) and has received legislative attention in the past 5 years from both the European Union (in the form of mandatory management plans from member states) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Appendix II listing) to help address decline in this species. There is a broad suite of proposed causal factors for the recruitment decrease that can affect every life stage—elvers and glass eels migrating upstream; freshwater yellow eels; and silver eels migrating downstream. These include; changes in oceanic currents and/or climatic conditions (e.g. Castonguay et al., 1994; Bonhommeau et al., 2008a, b); barriers to migration (including hydro-power stations which damage and/or kill eels) (e.g. Winter et al., 2006; Chadwick et al., 2007); overfishing (e.g. Feunteun, 2002; Dekker, 2003); loss of freshwater habitat (e.g. Feunteun, 2002); pollution (particularly lipophilic substances such as PCBs and substances that affect lipid storage) (e.g. Robinet & Feunteun, 2002; Pierron et al., 2007); poor condition of escaping silver eels (particularly in relation to insufficient lipid stores) (e.g. Svedäng & Wickström, 1997); and the effects of the swimbladder parasite *Anguillicoloides crassus* (e.g. Gollock et al., 2005). While the weight of evidence for some of these factors is greater than others, it is unlikely that there will be one single cause, and due to the oceanic nature of eel emigration, it is difficult to monitor the effects of these in the field.

Although a number of reports and papers that have assessed the available data on eel stocks in the UK (Bark et al., 2007), and more specifically, within the Thames (Naismith & Knights, 1988, 1993; Knights, 2005), little or no monitoring of elver migrating upstream has taken place in over 15 years. Several of the suggested tidal/freshwater causes for eel decline can be identified in the Thames catchment;

1. Barriers to eel movement: over 500 have been identified to date in the catchment that affect upstream and/or downstream eel movement;
2. Pollution: water quality in the tidal Thames remains an issue despite significant improvements in water treatment over the past 40–50 years because of the large amount of industrial development on its banks and discharges of raw sewage during storm events;
3. Development: this can result in bankside and riverbed encroachment which will affect eels directly by reducing the available feeding grounds, as well as the habitat of the prey species such as benthic invertebrates and other fish species.

A River Thames specific Eel Management Plan (EMP) has been drafted and several of the actions address these problems—eel passes are being constructed at a number of barrier sites; continued monitoring is being encouraged to increase the dataset and determine the effect of mitigating actions; and water quality samples are being taken to establish the presence of contaminants in certain rivers (DEFRA, 2009). This article describes the monitoring of upstream migration of juvenile eels in the Thames catchment and the implications for populations of the species.

## Materials and methods

Traps based on the design of Naismith & Knights (1988)—this requires a weir/lock to provide a head of water to supply the trap—were located on two tributaries of the Thames; River Darent (Acacia Weir—Ordnance Survey TQ543739); River Roding (Redbridge roundabout—Ordnance Survey TQ415883) and one site on the Thames itself (Molesey Lock, East Molesey—Ordnance Survey TQ152686). Where possible the traps were run during the expected period of upstream elver migration, i.e. from early April to late September dependant on weather conditions and water temperature (Naismith & Knights, 1988). Eels were returned to the river above the weir in order to prevent recapture, as migration behaviour suggests they will continue upstream against the flow. Trapping periods varied between sites over the 5 years—River Darent: 83–170 days; River Roding: 127–199 days; River Thames: 99–152—and this was corrected for using catch per unit effort (CPUE), i.e. fish caught per day, to allow comparison between inter-annual bi-weekly catch. The use of CPUE also corrected for the addition of a second trap at the River Roding in 2007—all sites otherwise used one trap. Mean CPUEs were compared with a non parametric one way Analysis of Variance (Kruskal–Wallis) and Dunn's post hoc test. Data were analysed using SigmaPlot v.11 (Systat Software Inc., Chicago). Statistical significance was accepted when $P < 0.05$.

## Results

The River Roding exhibited a 99.4% decrease in mean CPUE (fish per day) from $10.88 \pm 3.08$ in 2005 to $0.07 \pm 0.02$ in 2009 (Fig. 1). Analysis of variance indicated there were significant differences between years at the Roding site ($H = 92.89$, $P < 0.01$) and post hoc tests highlighted that CPUE in 2008 and 2009 was significantly lower than in each of the previous years between 2005 and 2007 ($P < 0.05$). There were no significant differences between years from both the River Darent and River Thames.

While we do not have CPUE data for dates prior to 2005, Naismith & Knights (1988) provide relevant information on total catches of eels from the River Darent between 1985 and 1987 caught over a similar seasonal sampling period (Fig. 2). The total number

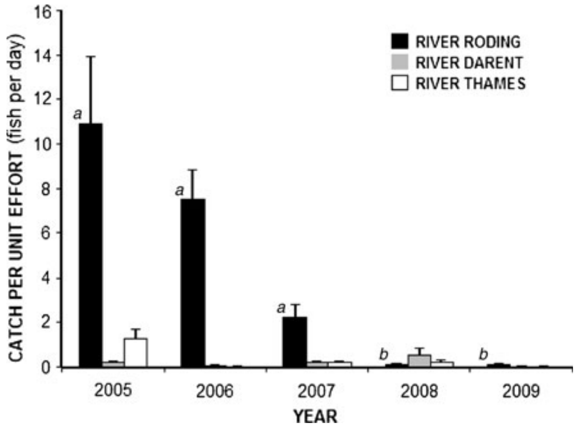


**Fig. 1** Mean *A. anguilla* catch per unit effort (fish per day) at three sites within the Thames river basin district—River Roding, River Darent and River Thames at Molesey Lock. Dissimilar letters indicate statistical differences within the River Roding data

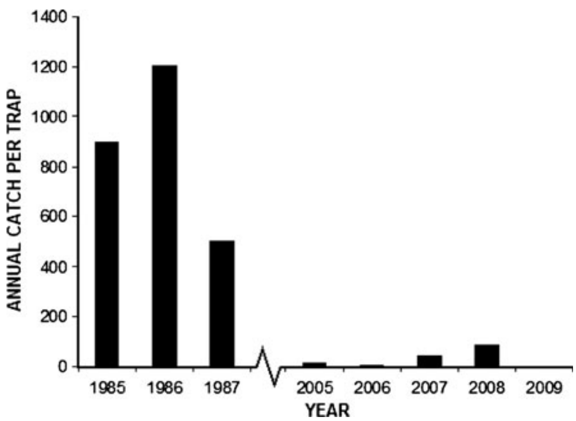


**Fig. 2** Total *A. anguilla* caught within the River Darent from 1985 to 2009. Data presented for 1985–1987 (Naismith & Knights, 1988) was halved in order to compensate for the increased effort of using two traps (2005–2009 data set was collected with a single trap). Methods and trap location are directly comparable between studies despite this increased effort

of eels caught decreased by 99.8% between 1985 ($n = 895$) and 2009 ($n = 2$) with this figure was similar in 1986. Post 2005 eel numbers were found to fluctuate at very low levels.

## Discussion

The results of the study indicate that the number of eels being recruited has significantly declined at one (River Roding) of the three sites analysed over a period of 5 years. However, the annual catches of eels at the Rivers Darent and Thames were very low (maximum catches per year were 85 and 143 eels, respectively), and in some years less than 10 were caught in total at both sites. Therefore, while there may have not been significant differences in CPUE, such low catches are of concern, particularly considering the comparatively high numbers previously recorded in the River Darent (Naismith & Knights, 1988). With a decline in recruitment, one could expect to see a decline in the downstream migration of silver eels. There is little if any monitoring of silver eel escapement on the River Thames, however, there has been analysis of yellow eel numbers caught on the Rivers Darent and Roding as part of Environment Agency (EA) routine electro-fishing surveys (Knights, 2005). There appeared to be no obvious trends in the data, however, surveys were carried out very intermittently, and more importantly they were not eel-specific (Knights, 2005). Due to their ability to remain sedentary in the substrate and amongst debris, the standard three pass quantitative electro-fishing survey used for multi-species assessment has been shown to underestimate eel numbers (Knights et al., 2001) with four or five passes and an increase in voltage required to properly assess this species (Environment Agency, 2009). Eel-specific surveys are only just being introduced by the EA at sites around the UK—including the Thames river basin district (DEFRA, 2009)—this is further evidence that the monitoring of this species, one whose recruitment appears to be in steep decline, is insufficient and needs to be improved.

Despite a number of suggested factors, there is still little understanding of the specific causes of the decline in eel recruitment across Europe. In relation to the present study, oceanic current changes and barriers to upstream migration are likely to have the most significant effects on the recruitment of juvenile eels to freshwater, particularly considering there is no glass eel or elver fishery on the Thames (DEFRA, 2009). Estimating and mitigating the effects of changes in the marine environment on the recruitment in the River Thames is complex, but research does indicate that they can have a significant effect (Bonhommeau et al., 2008a, b). At the River Roding, the only site where a significant decline, was observed there have been no changes in barriers or notable pollution incidents over the period of study that could potentially impact migration. As the site is six kilometres upstream from the tidal limit other factors, either in the estuary or the marine environment, may be impacting recruitment in the River Roding. It is also possible that such significant changes in numbers are having effects on density dependant movement of eels within the river (Clifton-Dey, personal communication). Further research is required to identify these factors.

It is clear that there is insufficient data to establish the cause or causes of the decline in eel recruitment in the River Thames catchment—be they anthropogenic or changes in natural processes. However, due to the extremely low numbers of eels that are presently being observed at all sample sites, it would seem pertinent to adopt a 'precautionary approach' and implement management actions that have the potential to cease or reverse the decline (Russell & Potter, 2003; Bevacqua et al., 2007). The Food and Agriculture Organisation of the United Nations (FAO) (1995) also noted that if a natural phenomenon has a significant adverse impact on the status of living aquatic resources, action should be taken to adopt conservation and management measures on an emergency basis to ensure that fishing activity does not exacerbate the problems. Thus, regardless of the cause of the decline, and in line with the 'precautionary principle' it is essential that a suite of monitoring projects is undertaken to both determine whether the decline continues, in order to elucidate the causal factors of the population changes.

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