The Thames European Eel Project Report

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- Canal and River Trust;
- Environment Agency;
- Friends of the River Crane Environment;
- Ham United;
- Historic Royal Palaces;
- Kingston University;
- Medway Valley Countryside Partnership;
- National Trust;
- North West Kent Countryside Partnership;
- Thames Anglers Conservancy;
- Thames Water;
- South East Rivers Trust;
- Surrey Wildlife Trust; and
- Wandle Heritage.

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Executive Summary

- The numbers of glass eels arriving each year, termed glass eel recruitment, has decreased by over 90% in the North Sea compared to the 1960-1979 average (ICES, 2016). In 2008, the International Union for the Conservation of Nature (IUCN) classified the European eel as Critically Endangered.

- In response to this reported decline, in 2005 ZSL established a monitoring project to determine the recruitment of elvers (juvenile eels) into the River Thames catchment and found a similar reduction. The study established that there were up to 99% fewer eels arriving than in the 1980's into the River Roding catchment.

- In 2011 the project expanded, incorporating citizen science, to become the largest elver monitoring scheme within a single catchment in the UK. The goals of the project are to monitor recruitment of the European eel into the Thames tributaries and to identify and make additional habitat available by allowing passage over barriers to upstream migrating European eel.

- The number of elver monitoring sites has increased from 3 in 2005 to 11 sites in 2018. This increase has been made possible through collaboration with local partners and the recruitment and training of citizen scientists.

- The monitoring data and subsequent barrier investigations have enabled an evidence-based assessment to inform management measures and prioritise barrier mitigation action, such as eel passes. Barriers to migration are identified as one of the major threats to eel populations in the Thames Catchment.

- This report summarises key findings from the monitoring data collected from 2005 to 2018.

- Catch per unit effort (CPUE) was calculated for each trap (number of elver caught per day) to assess changes in elver recruitment. The CPUE shows high variability, with large annual fluctuations and differences observed between sites.

- With five or more years of data for multiple sites, it is now possible to identify trends in the annual CPUE. At sites where trapping methodology and downstream barrier conditions remain unchanged, these patterns reflect what is being seen across Europe. Data provides evidence of the impact of improved eel passage downstream.

- In 2018, new installations include eel passes at Dorking Guaging Weir and Wilderness Weir on the River Mole, Hall Place on the River Cray and eel tiles at Loughton Weir on the River Roding. Over the duration of the project, ZSL and partners have installed eel passes which have made approximately 16 football pitches (137.03 hectares) of additional eel habitat accessible in the Thames catchment.

- To date, 867 volunteers and 22 partner organisations have been involved with the project. Multiple educational and outreach benefits have resulted through the training and empowerment of large numbers of individuals and organisations.

- This project is an example of the numerous benefits citizen science initiatives can provide for freshwater conservation. The Thames European Eel Project demonstrates that continued two-way communication between conservation practitioners and volunteers can sustain volunteer engagement to provide cost-effective, reliable and robust data that can be used to guide environmental management decisions.

Contents

1. Introduction

1.1. Background

The European eel, *Anguilla anguilla* (L.), has been listed as 'Critically Endangered' on the IUCN Red List since 2008 due to dramatic declines in abundance recorded across all stages of its life cycle and much of its natural range (IUCN, 2014). In 2007, the European Commission Regulation (EC no. 1100/2007; EC 2007) *'Establishing measures for the recovery of the stock of European eel'*, was enacted. This requires Member States, with habitat supporting the European eel, to develop mandatory Eel Management Plans for their river basin districts (RBD). In addition to this, the European eel is included within Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendix II of the Convention on Migratory Species (CMS).

The stages of the European eel life cycle are shown in Figure 1. Juvenile eels arrive on the coast as glass eels having drifted on ocean currents as leptocephali from the Sargasso Sea. The glass eels then pigment to form elvers during the early stages of their upstream migration. During their growth lifecycle stage they develop into yellow eels before metamorphosing into silver eels prior to commencing their migration back to the Sargasso Sea where they breed.

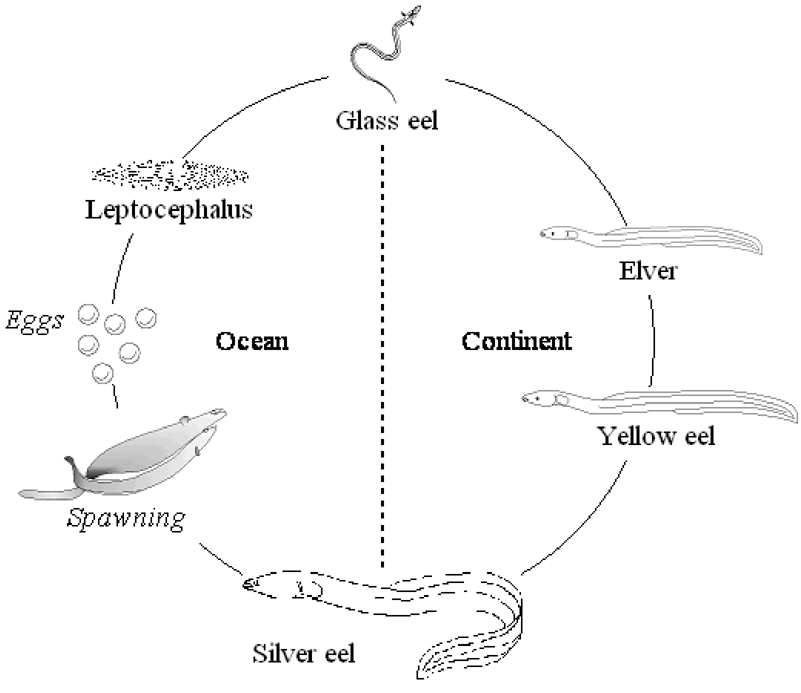


Figure 1: The life cycle of the European eel (Maes & Volckaert, 2007).

The Working Group on Eels (WGEEL) collates data from the monitoring of European eel populations across Europe. Whilst the recruitment levels have remained extremely low compared to the 1960's, from 2012 to 2014 an increase was observed, peaking in 2014 (Figure 2). This period saw recruitment in the North Sea increase to 3.7% of the 1960-1979 level from what had been less than 1%; and elsewhere in Europe saw an increase of 5% to 12.2% (ICES, 2014). Since 2014 however, recruitment levels have again been declining with the annual recruitment of glass eels across the North Sea in 2017 at just 1.6% of the 1960-1979 level; a further decline from the 2.7% level recorded in 2016. Such levels are below safe biological limits and therefore the population status of the European eel remains critical (ICES, 2016 & ICES, 2017).

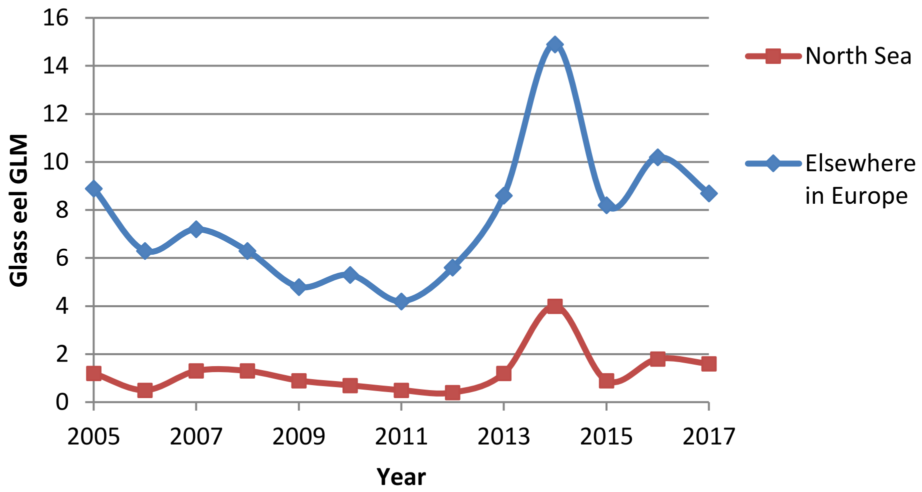


Figure 2: Glass eel recruitment indices for the European eel in the continental North Sea and 'elsewhere in Europe' from 2005 to 2017. (The data was taken from the 2017 ICES stock advice. Glass eel recruitment was predicted as a function of area, year and site giving the geometric means of estimated recruitment (GLM). This was fitted to 43 time-series', comprised of either a combination of glass eels and yellow eels or purely glass eels and was then scaled to the 1960–1979 geometric mean (ICES, 2017).

Several anthropogenic, oceanic and climatic factors have been identified as potential causes of the recorded decline in recruitment. They include the loss of habitat, pollution, barriers to migration, hydropower, and exploitation from commercial and recreational fishing (Feunteun, 2002; Dekker, 2003; Chadwick *et al.,* 2007). These pressures impact all life stages of the eel; affecting glass eel and elver survival and limiting silver eel escapement (Winter *et al.,* 2006; Piper *et al.,* 2012). Some studies have shown oceanic and climate variability impact the transport of larvae and recruitment of glass eels (Bonhommeau *et al.,* 2008; Baltazar-Soares *et al.,* 2014). These factors in-combination are likely to be responsible for the decline in eel recruitment in the UK (Jacoby *et al*., 2015).

1.2. Eels in the Thames

The Thames River Basin District (RBD) comprises 11% of the freshwater and lake habitat in England and Wales (EA, 2010). As a result, it has historically provided an important area of habitat for the growth stage of the European eel, supporting large population stocks (Wheeler, 1979; Naismith and Knights, 1988). However, South East England is a highly developed and densely populated area, with a long history of heavily engineered waterways. Barriers to migration, in the form of flood defences and weir construction, have been identified as a major threat to eel migration (DEFRA, 2010). There are 2,412 structures which are potential barriers to upstream migration within the Thames RBD

(Clifton-Dey, D., pers. comm., 2016). It is likely these structures prevent access to suitable habitat by blocking upstream migration, leading to patchy distribution and reduced eel production in the Thames RBD compared to historical records.

1.3. ZSL Monitoring Programme

ZSL began monitoring upstream elver migration in the Thames tributaries in 2005 to compare levels of elver recruitment against levels in the 1980s. The focus of the monitoring between 2005 and 2011 was at three sites on the Rivers Darent, Roding and Mole. Traps are placed at river barriers and upstream eel movement is monitored from April to October, during the elver migration season. Long term datasets from these sites have provided an insight into the decline of the European eel, identifying a 99% decrease in elver recruitment in the Roding Catchment compared to the 1980s (Gollock *et al.,* 2011). Monitoring sites on the Rivers Mole and Darent were closed in 2017 due to eel pass installations on the former and river engineering works on the latter but monitoring on the Roding continues. Data from the site are sent annually, via the Environment Agency, to the Joint European Inland Fisheries and Aquaculture Advisory Commission / International Council for the Exploration of the Sea / General Fisheries Commission for the Mediterranean (EIFAAC/ICES/GFCM) and WGEEL. These are used along with other datasets to inform eel stock management advice from the WGEEL.

Since 2011, the scope of the Thames European Eel Project has increased through the creation of a citizen science monitoring scheme. Volunteers and the support from 22 partnership organisations have enabled citizen science monitoring of the upstream eel migration at 15 sites between 2011 and 2018 (figure 3). ZSL provide training, monitoring equipment and some of the traps. Licenses and some traps have been supplied by the Environment Agency. The South East Rivers Trust (SERT), National Trust and the Thames Rivers Trust have also provided monitoring traps used within the project.

2. Method

2.1. Trap Locations

A map of the 11 sites monitored in 2018 is shown in Figure 3. Through a close working relationship with the Environment Agency chaired Eel Management Plan Implementation Group (EMPIG), ZSL take every opportunity to monitor new passes built in the region. Monitoring can only happen, however, where partnership groups are available to monitor traps and access to the site is safe. The project has expanded further in 2018 with monitoring recommencing at Cray-Hall Place after a four-year break.

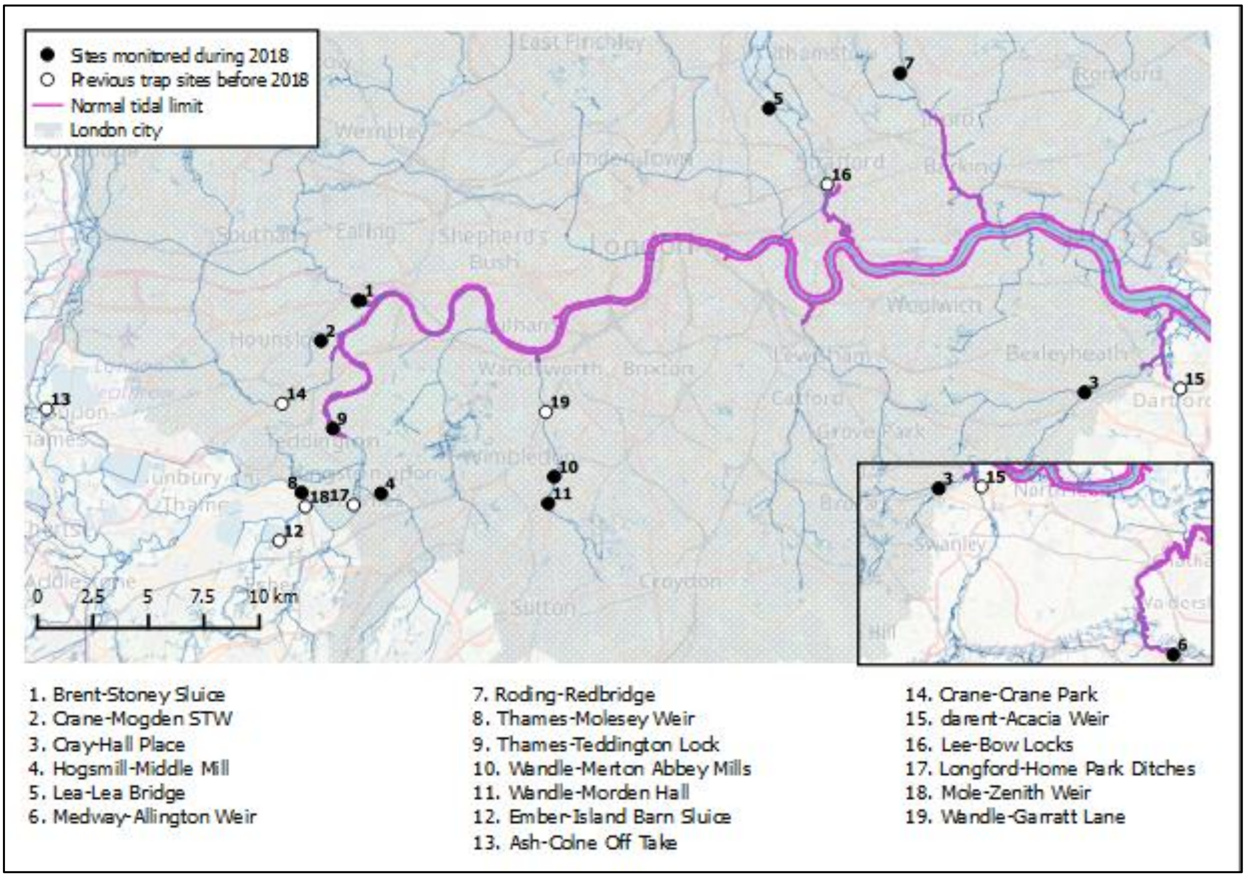


Figure 3: Locations of the monitoring sites within the Thames catchment prior to 2018 and present. Map created using QGIS©

2.2. Site Selection

Selecting sites within the Thames catchment for eel monitoring has been governed by several factors. These include:

- A need to understand the spatial and temporal pattern and distribution of eel migration throughout the Thames RBD.

- Choosing sites lower down in a river system closer to the tidal confluence since these provide a better and more immediate indication of eel recruitment within any year.
- Practical considerations, such as where both partnership organisations and volunteers are available to monitor and sites where access to an eel pass is safe to do so.

2.3. Trap Design

Traps are installed at barriers within rivers which impede upstream eel migration. This is a straightforward approach to monitoring glass eel and elver migration as they congregate while attempting to find an upstream passage (Harrison *et al.,* 2014). The basic trap design, as developed by Naismith and Knights (1988), is shown in Figure 4. The water flowing down a media filled trough from the water pipe attracts eels, encouraging them to climb up the trough and into the holding tank that provides a safe refuge for them away from direct sunlight (EA, 2011a; Piper *et al.,* 2012). While based on the same design principles, the traps at each site differ, example shown in Figure 5. As a result, the trapping performance will also differ, and therefore direct comparisons of catches between sites should only be made with an understanding of the performance of the traps used.

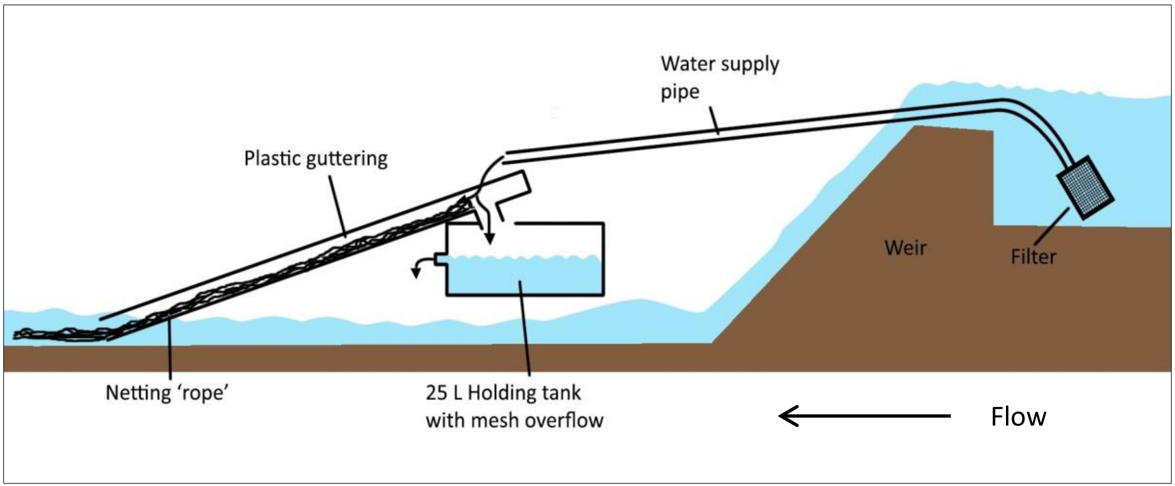


Figure 4: Schematic of the basic trap design used within the ZSL monitoring project.

Figure 5: Two of the different types of traps used for monitoring. (a) a gravity supplied trap at Hogsmill-Middle Mill, and (b) a pumped trap at Crane-Mogden Sewage Treatment Works (STW).

Table 1 gives a broad assessment of the performance of the traps used in the monitoring project. Trap performance provides an indication of the proportion of the total number of eels moving upstream at the trapping site that might be caught by each trap. Those traps with a high-performance rating are assumed to be trapping a higher proportion of passing eels compared to medium or low performing traps. It is used as a guide only to inform analysis of the catch data.

Trap performance varies according to:

- The presence or absence of a bypass channel around the trap. Performance decreases with the presence of a bypass route that avoids the trap.
- The wider the river channel that the trap is positioned on, the lower the performance rating.
- The more impassable the barrier that the trap is positioned downstream of, the greater the performance of trapping.

Table 1: The Performance rating of the eel traps used in the project

Site	Efficiency rating
Ash- Colne Off Take	Medium
Brent- Stoney Sluice	High
Crane- Crane Park Island	Low
Crane- Mogden STW	Medium
Cray- Hall Place	Medium
Darent- Acacia Weir	Medium
Ember- Island Barn Sluice	High
Hogsmill- Middle Mill	Medium
Lea- Bow Locks	Low

Lea- Lea Bridge	High
Longford- Home Park	High
Medway- Allington Lock	Medium
Mole- Zenith	Low
Roding- Redbridge	Low
Thames- Molesey Weir	Low
Thames- Teddington Lock	Low
Wandle- Merton Abbey Mills	High
Wandle- Morden Hall	High

2.4. Citizen Scientist Training and Monitoring

Citizen scientist monitoring started in 2011. All volunteers are inducted via a two-hour training session onto the project. Training includes: an introduction into eel biology with an overview of possible causes of eel population decline, the purpose and outputs of survey work, methods of checking the trap and measuring eels, along with a demonstration of how to use the online portal for data submission. Volunteers are shown how to capture, process and release eels at a trap. All volunteers on the project undertake a classroom-based health and safety briefing, plus read and sign risk assessments prepared for each site. These training sessions have been attended by 102 new volunteers in 2018 taking the cumulative total to 867 since the project launch in 2011. Each trap site has a lead coordinator or coordinating partnership organisation.

Trapping starts in early April and stops by the last day of September. This 6-month period covers the peak time of upstream eel movement in the Thames RBD. Increasing water temperatures simulates upstream eel migration. A threshold for enhanced migratory behaviour peaks at 14-16°C, no or little migration occurs beneath 10-11°C (White and Knights 1997). Traps are inspected at least twice per week during the monitoring period. The frequency of trap inspections ensures elvers are never held in the traps for longer than four days. At some sites, where catches become greater than 100 eels per day, the frequency of inspections is increased and can be completed as often as daily. The length of trapped eels is measured and recorded at all sites (Figure 6). Where more than 50 eels are recorded, a sub-sample of 50 eels are randomly selected and measured to provide a representative sample of all the eels trapped on that occasion. Following measurement, eels are released back into the river, near the bank edge, upstream of the barrier. To avoid volunteers handling large eels, those estimated to be longer than 300mm are released without measuring and recorded on the database as >300mm. Eel trapping is permitted under the Salmon and Freshwater Fisheries Act, 1975, by the Environment Agency.

Figure 6: Trained citizen scientists and ZSL staff collecting and measuring eels.

The aim is to have a minimum of three years data collected from each site and then close the monitoring. Exceptions to this are our index sites, Roding-Redbridge, Medway-Allington Lock and Thames-Molesey Weir, where the development of a data time series in being produced to inform on long-term recruitment trends. Where the volunteers are willing, monitoring beyond three years at citizen scientist sites is encouraged as longer-term data sets have more value in showing trends in upstream freshwater eel migration.

2.5. Data Processing

Eel counts, eel length measurements, the date of the survey and the citizen scientist's name are uploaded to a database on the ZSL website with restricted access. Here ZSL staff quality check the data and, if necessary, contact citizen scientists to validate any unusual records. Training is provided and a thorough data checking and validation process is embedded in the methodology to ensure the quality of the data, in line with recommendations in Tweddle et al. 2012.

Trapping duration at each site varies between years due to occasional trap failure. Trap failure is documented to enable a record of the total number of days the trap is active over the monitoring period, termed the "effort". The total number of eels caught is divided by the total number of successful trapping days in order to calculate the catch per unit effort (CPUE). This accounts for annual variability in trapping effort as a result of trap failure. It is vital that any comparison of catch between years recognises the effort made and therefore a more useful comparison of elver recruitment over time is made using CPUE.

Catch totals and CPUEs for all sites are supplied to the Thames RBD, Eel Management Plan (EMP) annually; eels <120mm are recorded and reported separately in line with the EU Eel Regulation (EC no. 1100/2007; EC 2007). The production of graphics and data analysis has been carried out using MS Excel.

3. Results

3.1. 2018 Catch Totals

A total of 80,998 eels have been recorded in 2018 (Table 2) (appendix A). This includes 63,940 eels caught at Brent-Stoney Sluice, the site where the highest number of eels were recorded. This figure is 2.1x higher than the total number of eels caught at Brent-Stoney Sluice the previous year.

Elvers, eels of <120mm, are used in this study to show recruitment. The proportion of elver to yellow eels remained similar across most sites, however a few sites showed a reduction in proportions of elvers, such as Lea-Lea Bridge and Hogsmill-Middle Mill compared to 2017. In comparison, the proportion of elvers displayed has risen at some sites including Wandle-Merton Abbey Mills. The percentage of the annual catch recorded as elver is also shown in Table 2.

3.2. CPUE – Catch Per Unit Effort

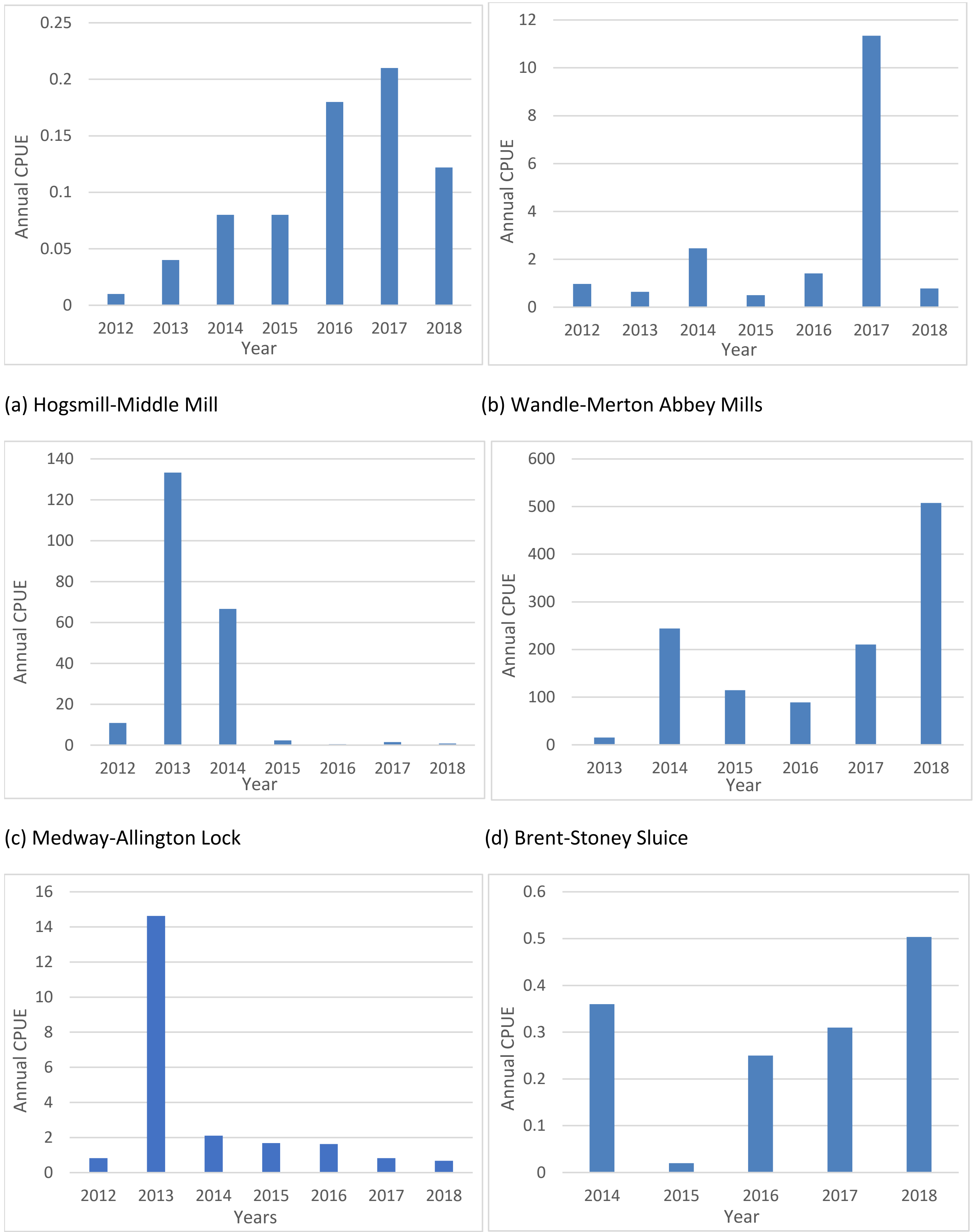
The annual mean CPUE, 2011 to 2018, for each site is shown in Table 3. CPUE fluctuates between years across most sites and shows high variance from the mean within a single season. Of the 10 sites that were monitored in both 2017 and 2018, 7 recorded a reduction in CPUE and 3 recorded an increase. Brent- Stoney Sluice, a high performing trap, has recorded the highest CPUE in 2018, significantly larger than the CPUE from the previous year and compared to the other monitoring sites. Brent-Stoney Sluice has recorded the highest CPUE for a fifth consecutive year.

Annual CPUE from sites, that have been monitored for 5 years or more, are illustrated in Figure 7. A range of trends are displayed including gradual increases over time with the highest peak being in 2018 at two monitoring sites. Four sites display a reduction in CPUE from the previous year, while two sites present clear peaks in CPUE compared to the other monitoring years, these being Wandle-Merton Abbey Mills in 2017 and Thames-Molesey Weir in 2013. Figure 8 shows the CPUE data for Roding-Redbridge from 2005, when monitoring at the site started, to 2018. The CPUE displays an increase compared to the previous year and correspondingly a gradual increase since 2016. 2005 remains the year of highest CPUE at Roding-Redbridge. This ZSL staff monitored site provides a valuable long-term data set.

The annual CPUE at Cray-Hall Place is shown in Figure 9. Monitoring at this site started in 2011 but stopped in 2013 having collected three years of data. Citizen science monitoring recommenced at Hall Place this year following the insertion of an eel pass further down river in early 2018. The annual CPUE displays a peak in 2018 compared to the previous three years of monitoring.

Table 3: Annual CPUE (eel day^{-1}) per site.

Site	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Ash-Colne Off Take	-	-	-	0.27	0.1	0.1	-	-
Brent-Stoney Sluice	-	-	15.3	244.31	114.63	88.94	210.29	507.46
Crane-Crane Park Island	0	0	0	-	-	-	-	-
Crane-Mogden STW	-	-	-	-	5.96	6.35	3.87	0.93
Cray-Hall Place	0	0.01	0.04	-	-	-	-	0.11
Darent-Acacia Weir	-	0.16	0.02	1.21	0.08	0.09	-	-
Ember-Island Barn Sluice	-	-	-	-	-	-	6.81	-
Hogsmill-Middle Mill	-	0.01	0.04	0.08	0.08	0.18	0.21	0.12
Lea-Bow Locks	-	0.09	1.48	2.98	0.61	0.88	-	-
Lea-Lea Bridge	-	-	-	-	-	56.57	132.95	98.925
Longford-Home Park	-	-	0.62	2.82	2.53	2.31	-	-
Medway-Allington Lock	-	10.9	133.3	66.68	2.34	0.48	1.49	0.76
Mole-Zenith Weir	-	1.25	0.09	0.1	0.52	-	-	-
Roding-Redbridge	-	0.08	0.47	7.2	2.36	0.83	1.15	3.61
Thames-Molesey Weir	-	0.82	14.63	2.1	1.68	1.63	0.82	0.67
Thames-Teddington Lock	-	-	-	0.36	0.02	0.25	0.31	0.50
Wandle-Merton Abbey Mills	0	0.97	0.64	2.46	0.5	1.41	11.34	0.79
Wandle-Morden Hall	-	-	-	-	-	-	2.43	1.64
Annual CPUE	**0**	**1.59**	**15.14**	**27.55**	**10.11**	**12.31**	**33.79**	**49.78**



(a) Hogsmill-Middle Mill

(b) Wandle-Merton Abbey Mills

(c) Medway-Allington Lock

(d) Brent-Stoney Sluice

(e) Thames-Molesey Weir

(f) Thames-Teddington Lock

Figure 7: Annual CPUE for 2018 citizen science sites with five or more years data.

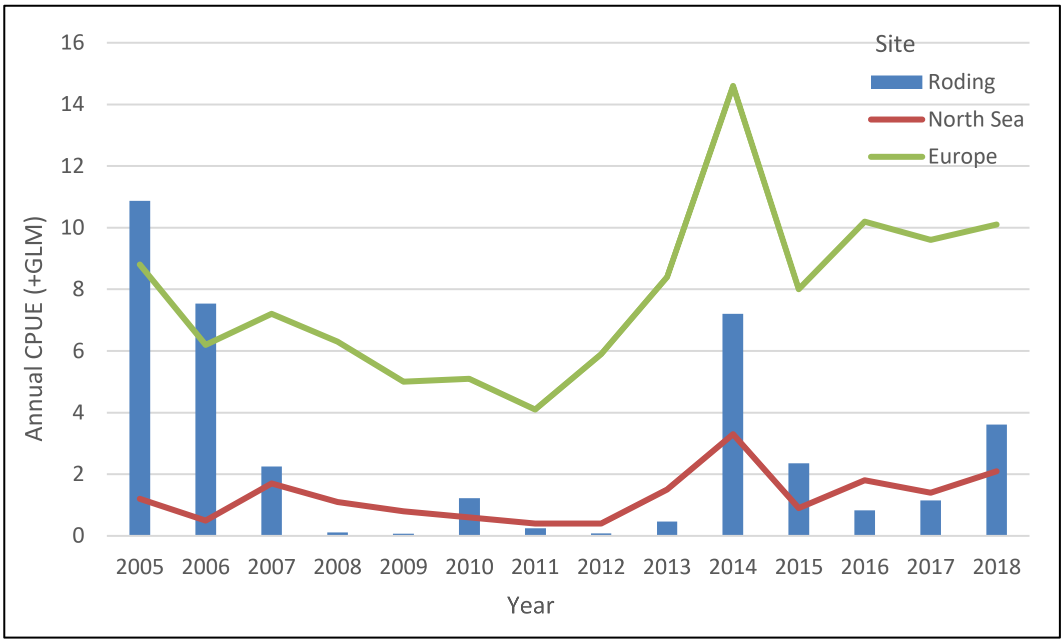


Figure 8: Annual CPUE for Roding- Redbridge since monitoring began in 2005 with ICES recruitment index for North Sea and Europe.

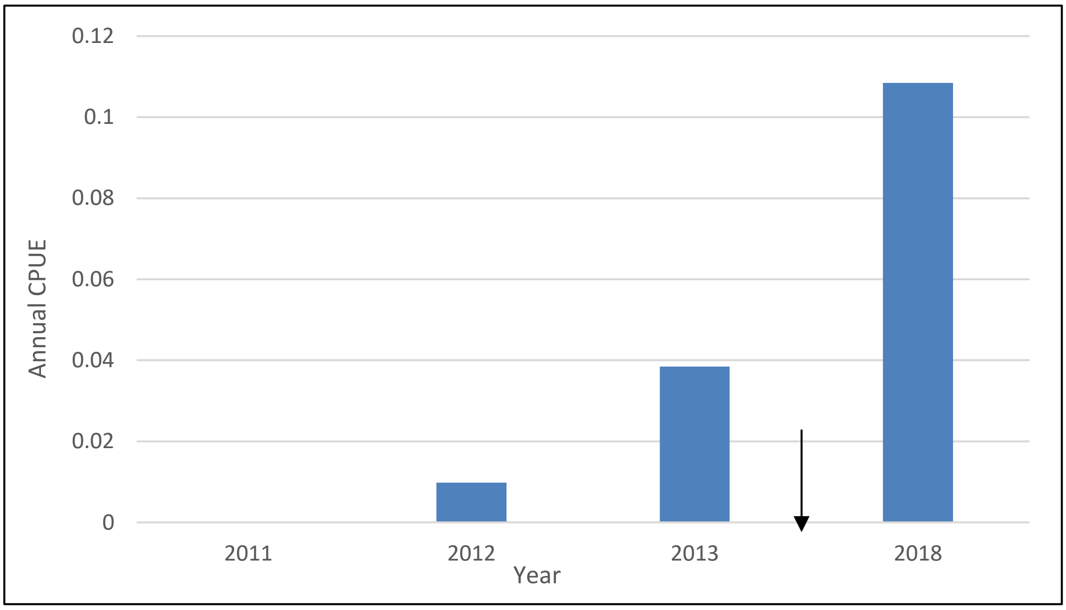
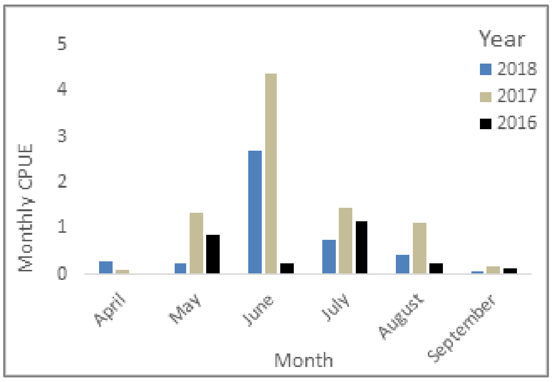
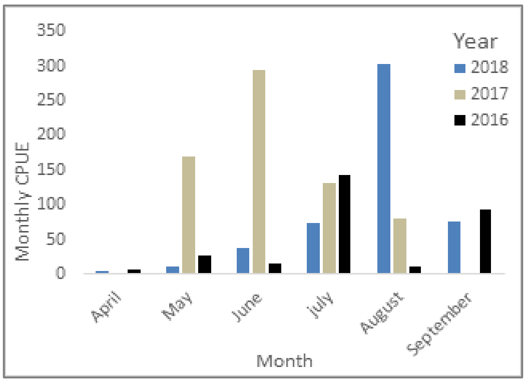


Figure 9. Annual CPUE for Cray-Hall Place. Eel pass assembled on river Cray early 2018. Pass installed on river Cray early 2018.

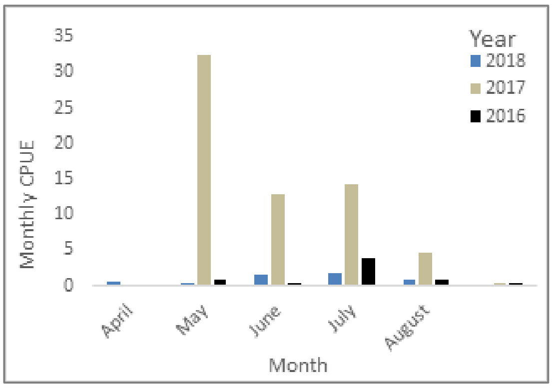
The monthly CPUE for five citizen science monitoring sites, across three years, is shown in Figure 10. All sites shown have been monitored for five or more consecutive years. Brent-Stoney Sluice displays clear peaks in monthly CPUE during August and September between 2016 to 2018, the highest peak in CPUE presented in August 2018. In comparison, three other sites, Lea-Lea Bridge, Medway-Allington Lock, Thames-Molesey Weir, show a rise in monthly CPUE during mid-season before a decline. The monthly CPUE at Wandle-Merton Abbey Mills remains low across the years, although a rise in CPUE in 2017 is presented during mid-summer.



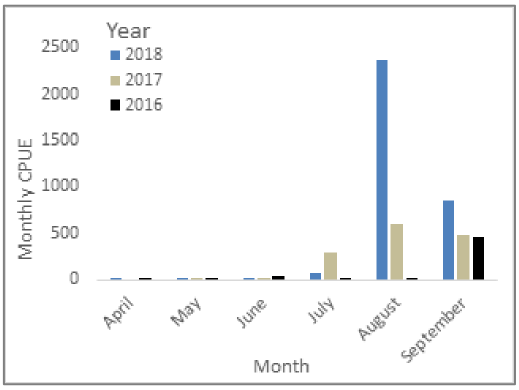
a) Medway-Allington Lock



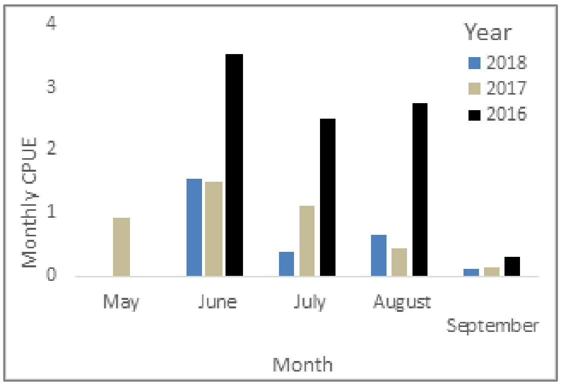
b) Lea-Lea Bridge



c) Wandle-Merton Abbey Mills



d) Brent-Stoney Sluice



e) Thames-Molesey Weir

Figure 10: Monthly CPUE across three years at five citizen science monitoring sites in order of closest to further distance from estuary mouth.

4. Discussion

4.1. Catch Data

As a consistent methodology for monitoring eel recruitment throughout the Thames RBD has now been used at 10 sites for five or more years, the data provides a useful source of information on changes in recruitment over time. By having multiple sites we can also infer recruitment trends into the wider Thames RBD.

Recruitment continues to be low when compared to levels of recruitment recorded prior to the 1980s (ICES, 2017), and most sites show a pattern of recruitment similar to those observed in other catchments in the North Sea (ICES, 2017), and across Europe (Figure 2), where a small peak in recruitment was observed in 2014 (ICES, 2014). Traps on the River Brent-Stoney Sluice, Roding-Redbridge and Wandle-Merton Abbey Mills all experienced an increased CPUE in 2014 compared to the years either side and Medway-Allington Lock and Thames-Molesey Weir had a more prominent peak in 2013, within the 3-year time period during which the increase was observed across Europe (Figures 7 & 8) (ICES, 2014).

The large spatial distribution of sites also allows us to see patterns of recruitment within the Thames RBD. Generally it is the sites nearest the tidal limit on the tributaries that catch a higher proportion of elver. The proportion of yellow eel in the catch increases with distance from the tidal limit. There are exceptions to this however, such as Thames-Molesey Weir.

The variability in results between rivers is fascinating, with some tributaries seemingly receiving the bulk of the eel recruitment, whilst others have very few. Knowing whether these are real differences in relative eel numbers travelling up rivers or whether variability is down to differences in trapping efficiency, is a limitation of the methodology. Trap efficiency is impacted by a number of factors including; the position of the entrance of the trap ladder in the river and the hydrodynamic conditions at the entrance of the ladder (Piper et al. 2012), the passability of the barrier or presence of bypass channels that eels can use to avoid the trap. For this reason, provided the trapping method is consistent, the data has most value in assessing variations over time at a particular site and only enables conservation mangers to draw broad conclusions about the variation in catch numbers between sites. For a more complete understanding of eel stock ecology in the Thames RBD, citizen science upstream migration monitoring should be accompanied by a suite of other research projects including; monitoring of yellow eel stock and silver eel escapement (the migration of silver eel to the Sargasso Sea to spawn) and acoustic telemetry studies aimed at improving our understanding of eel behaviour in the Thames RBD.

4.2. Timing of the upstream migration

Although the monitoring shows a defined 'monitoring season' there is surprising variation between sites in the timing of peak catches within this (Figure 10). Over the past three years Brent-Stoney Sluice has displayed a peak in monthly CPUE towards the end of the monitoring season. Comparatively, peaks in catch appear to occur across mid-summer at Medway-Allington Lock, Thames-Molesey Weir and Wandle-Merton Abbey Mills. Examining monthly CPUE help us to determine patterns in yearly recruitment of elvers between the rivers and associated monitoring sites across London. Knowing when eels are moving upstream is important for conservation managers as the information is used to restrict in-river activities that might otherwise interfere with normal migration, for example percussive piling or dredging, both of which could harm or delay successful fish migration (Kjelland et al. 2015). In addition to knowing when eels are moving, conservation managers need to know the size distribution of eels in rivers.

4.3. Distribution of elver in the RBD

The data show a weak negative correlation between percentage of catch recorded as elver and the distance of the site from the tidal limit (table 2). This information on which lifecycle stage makes up the highest percentage of catch within the various river sections of the catchment, is needed to advise regulators on appropriate screen size selection to prevent elvers being killed by abstraction pumps. Entrainment and impingement of eel at abstraction points, cooling water intakes and tidal power plants can be a major cause of eel mortality in some rivers (DEFRA 2010). Under the Eels (England and Wales) Regulations 2009, the Environment Agency has the powers to require that abstractors screens are placed on intakes to prevent harm to eel stocks. Screen designs, approach velocity of the abstracted water, and slot width of the screen are all dependent on the presence and size of the eels in the vicinity, which is determined by either direct monitoring, or inferred presence from other studies.

4.4. Migration Barriers and Passes

Being mindful of differing trapping performance ratings, monitoring data allows for a comparison of catches across sites or, perhaps more importantly, a comparison between actual and expected catch for a site. Low or zero catches at sites may indicate barriers to migration located downstream of monitoring sites. The ideal for eel migration and the wider river ecology is barrier removal, but where this is not feasible the installation of eel passes can help mitigate impacts. Several examples of the positive, localised impact of eel passes have been highlighted by the monitoring data. For instance, Figure 9 shows CPUE from Cray-Hall Place increasing over time following the installation of an eel pass on the Cray in early 2018 improving accessibility. Work downstream, carried out by the Environment Agency at Crayford Gauging Weir in 2016, has helped to improve accessibility for upstream migration. The River Crane is also an example of this. In 2011 and 2013 the trap monitored at Crane-Crane Park Island (CPI) caught no eels, prompting the installation of two eel passes that allow eels to migrate up into the Crane catchment, via the Duke of Northumberland's River, from the Thames. One of these passes, at Crane-Mogden STW, contains a trap and monitoring of this trap has recorded the recruitment of eels to the catchment every year since its installation in 2015. There are no barriers on the River between Crane-Mogden STW and Crane-CPI. In future years, in order to directly gauge the impact of the new eel passes, it will be of interest to re-monitor at Crane-CPI using the same trap used in 2011 to 2013.

Since 2005, the project has been using passes with traps to restore migratory pathways. In addition, eel passes have been built without traps, as listed in table 4.

Table 4: Eel passes (without traps) built by the ZSL Thames European Eel Project since 2013.

Year	**Site**	**Location**	**Funder**
2013	River Darent	A24 Road bridge	Esmee Fairbairn Foundation
2014	River Hogsmill	Clattern Bridge	Esmee Fairbairn Foundation & SERT
2015	Duke of Northumberland's River (Crane Catchment)	Kidds Mill	SITA Trust
2015	River Brent	Osterley Weir	SITA Trust & Environment Agency
2016	River Mole	Zenith Weir	SITA Trust
2017	River Roding	Passingford Mill	BT
2018	River Roding	Loughton Gauging Weir	BT
2018	River Mole	Dorking Gauging Weir	European Maritime Fisheries Fund and Disney Conservation Fund
2018	River Mole	Wilderness Weir	European Maritime Fisheries Fund and Uniper

To date, the cumulative total of eel habitat made accessible by both the project's monitoring sites and the eel passes is calculated to be 137.03 ha. DEFRA's eel population model estimates that 5.88 kg silver eel biomass, escapes from each hectare of habitat in the Thames RBD (DEFRA, 2015). This means that as a result of this project a further 805.76kg of silver eels are expected to escape to the Sargasso Sea per year.

4.5. Partnership Support

A key objective of the project is to support our partnership organisations in taking measures that contribute to the conservation of the European eel. ZSL do this by offering technical advice on improving eel passage, highlighting funding opportunities, supporting funding bids and assisting with eel pass and easement installations.

In 2018, ZSL has produced a field guide for assessing the passability of man-made river structures by European eels entitled the Eel Barrier Assessment Tool (EBAT). This step-by-step guide has been designed for use by NGOs, consultants and regulators to aid in determining structure passability. The user can record the basic parameters of a structure and its bankside environment to produce a course assessment to help influence and prioritize future pass installations to notable barriers. Assessing the passability of structures is important so that barriers to migration can be eliminated and conservation benefits maximised.

Access to EBAT is available through the ZSL website:

http://www.zsl.org/eels

4.6. Project Plans for 2019 and Beyond

In 2019 the project will include:

- The installation of a pass, funded by the European Maritime Fisheries Fund, at Vitbe Sluice (TQ 52797 75399) on the River Cray (subject to a permit from the Environment Agency).
- In 2019, the programme will complete the delayed eel passes at Redbridge roundabout (TQ 5415 1883) on the River Roding, as the final task in the remaining works related to alternative measures payments from BT.
- ZSL will work with Thames21 on the River Brent to install a pass and monitoring trap at Costons Lane Weir (TQ 15807 78949) and improve passage at Stoney Sluice.

4.7. Project Impact and Citizen Science Engagement

The project has been a success thanks to the significant commitment of partnership organisations and volunteer citizen scientists. Some volunteers and organisations have remained engaged with the project over eight years, allowing consistent monitoring data to be collected across a large area. To date, 22 partner organisations and 867 volunteers have been involved within the programme, representing the significant capacity of the project to raise awareness and deeper understanding amongst the public of the issues facing the European eel in the Thames RBD.

One factor that has contributed to continued participation of citizen scientists has been a sustained two-way communication between conservation practitioners and volunteers. The project officer has remained readily available and responsive to project partners and citizen scientists. At the end of each migration season, all citizen science volunteers involved in the project are invited to the 'Citizen Science Eel Forum' (Figure 11). The forum gives ZSL an opportunity to thank volunteers, provide feedback on the outputs of the project and also encourages a free-flow exchange of information and ideas between citizen scientists and the invited expert speakers.

Figure 11: Citizen Scientists at the 2018 Annual Eel Forum.

The sustained high level of engagement of project participants has enabled the programme to develop into the largest single catchment study of elver migration within the UK. The project demonstrates that citizen scientists provide a cost-effective contribution to freshwater conservation at a catchment scale and produce a reliable source of data to advise regional, national and international conservation management.

It is important to recognise that the European eel status still remains 'critical' (ICES, 2017). Eels have a long generation period so the impacts of recent conservation efforts across Europe are unlikely to be observed for at least several years and up to a decade (ICES, 2014). The continuation of elver recruitment monitoring to assess longer term recruitment trends is considered to be of high importance.

For full details of barrier assessment reports and future projects please contact ZSL.

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Appendix

Site Name	Distance from tidal limit (km)	2012	2013	2014	2015	2016	2017	2018
Ash-Colne Off Take	28.6	-	-	27 (0%)	16 (0%)	16 (6%)	-	-
Brent-Stoney Sluice	0	-	1,239 (75%)	36,646 (91%)	20,410 (86%)	12,985 (75%)	30,071 (83%)	63,940
Crane-Crane Park Island	4.2	0	0	-	-	-	-	-
Crane-Mogden STW	2.2	-	-	-	565 (51%)	946 (58%)	588 (40%)	150 (17.3%)
Cray-Hall Place	2.9	1	3	-	-	-	-	9 (12.5%)
Darent-Acacia Weir	0.5	45 (36%)	9 (89%)	466 (97%)	26 (73%)	26 (88%)	-	-
Ember-Island Barn Sluice	7.7	-	-	-	-	-	75 (26%)	-
Hogsmill-Middle Mill	3.8	1 (0%)	7 (58%)	11 (83%)	13 (30%)	27 (19%)	34 (47%)	20 (15%)
Lea-Bow Locks	0	13 (100%)	208 (71%)	399 (88%)	121 (83%)	133 (85%)	-	-
Lea-Lea Bridge	6	-	-	-	-	8,089 (39%)	20,474 (37%)	15,828 (4.7%)
Longford- Home Park	4.5	-	49 (98%)	240 (75%)	316 (87%)	173 (73%)	-	-
Medway-Allington Lock	0	1,079 (91%)	12,802 (99%)	4,934 (99%)	421 (99%)	75 (97%)	115 (96%)	130 (99.2%)
Mole-Zenith Weir	7.8	138 (23%)	18 (82%)	19 (89%)	90 (58%)	-	-	-
Roding-Redbridge	6	11 (60%)	113 (75%)	2,318 (96%)	404 (71%)	156 (92%)	140 (79%)	347 (72%)
Thames-Teddington Lock	0	-	-	10 (100%)	5 (100%)	33 (100%)	47 (97%)	76 (100%)
Thames-Molesey Weir	8.1	133 (23%)	2,473 (99%)	327 (98%)	261 (96%)	250 (87%)	117 (85%)	64 (70.3%)
Wandle-Merton Abbey Mills	5.5	139 (14%)	69 (32%)	332 (25%)	68 (3%)	213 (7%)	1,497 (7%)	129 (34.9%)
Wandle- Morden Hall	6.2	-	-	-	-	-	241 (2%)	305 (12.8%)
Total number of eels		**1,559**	**16,987**	**45,729**	**22,716**	**23,122**	**54,102**	**80,998**

Appendix A Table 2: Distance from the tidal limit and total number of eels caught at each site. Values in brackets represent the percentage of the catch that are elvers (body length <120mm).