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Dynamics of glass eels in the Bristol Channel 2012-2013

Dynamics of glass eels in the Bristol Channel 2012 - 2013

Sarah Walmsley, Jon Barry, James Pettigrew

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Table of contents

List of Tables and Figures

Tables

Figures

Preface

In 2007 British Energy (now EDF Energy) commissioned Cefas to undertake a programme of scientific studies (the British Energy Estuarine and Marine Studies, or BEEMS Programme) to support the assessment of potential new nuclear builds including the proposed Hinkley Point ‘C’ (HPC), in Bridgwater Bay. The Programme encompasses evaluation of the potential physical, chemical and biological impacts of the development upon the marine environment.

One of the areas of study has been the potential impact of the proposed HPC on the European eel *Anguilla Anguilla* which is a priority conservation species managed under EU regulations across its European range including the Bristol Channel / Severn Estuary. Eel management in England and Wales is the responsibility of the Environment Agency. The species migrates up the Bristol Channel as recruiting glass eels, returning to sea many years later as adult or silver eels. As such the species is potentially vulnerable to entrainment at Hinkley Point (passing through the cooling water system) as glass eels and to impingement (capture on the station drum screens) as adults.

Little was known about the behaviour and distribution of recruiting glass eels in the Bristol Channel and so a scoping survey was undertaken by BEEMS in February 2012. This survey was scheduled to be repeated by BEEMS in 2013 to validate the observations made in 2012. As part of their responsibilities, the EA are interested in developing methods for monitoring glass eel recruitment in the Severn. With agreement from EDF Energy, a collaboration was agreed between the EA and Cefas, whereby the EA would contribute additional funding that would enable the 2013 study to be extended to cover a wider time period with a view to gaining further understanding of temporal variation of glass eel recruitment patterns. It was agreed that he intellectual property in the results would be jointly owned by EDF Energy and the EA and that the results would be published in a scientific paper. As a result of the collaboration and the additional funds available from the EA, the BEEMS programme was able to repeat the 2012 survey work in February 2013 and to complete an additional 7 day survey during April 2013.

Executive summary

European eel *Anguilla anguilla* is a priority conservation species managed under EU regulations across its European range including the Bristol Channel / Severn Estuary. As such, it has been of interest to the Hinkley Point new nuclear build programme in the context of cooling water abstraction for the proposed Hinkley Point 'C' (HPC) power station. The abundance and distribution of juvenile *A. anguilla* (also known as glass eels or elvers, depending on their size / age-class) in the vicinity of the current Hinkley Point 'B' (HPB) and proposed HPC intakes, and in the wider Severn Estuary/ Bristol Channel were investigated in February-March 2012, with the purpose of trialling novel sampling techniques for this species (prior to 2012, surveying for glass eels in such a wide estuary environment had not been undertaken). In 2012, the glass eels were distributed throughout the area surveyed, but were apparently in highest abundances in the surface waters and inshore on the English side of the estuary where the bottom topography is composed of gently-sloping muddy substrates.

As with any population study, estimating abundance or distribution based on one time point can be difficult, due to temporal fluctuations in movement, reproduction and recruitment. Thus, this report presents the results of two further surveys undertaken in February-March (14 days) and April 2013 (7 days), with the purpose of verifying the patterns of relative distribution and abundance observed in 2012, and investigating variability in eel abundance between the two years and within a recruitment season.

The survey methodology followed that of the 2012 survey. Sampling was conducted at several fishing sites within the Bristol Channel, with fishing sites being designated by their locality or physical location (e.g. off the mouth of the River Parrett, denoted 'Parrett'). Several fishing sites (Hinkley Point B, Hinkley Point C, English Parallel, Lilstock, Parrett) were sampled in the vicinity of the current Hinkley Point 'B' intake (HPB) and the proposed Hinkley Point 'C' intakes (HPC). Figure 1 shows the positions of those fishing sites in 2012, and similar positions were fished at those areas in 2013. The data for these eleven fishing sites were later grouped into four larger sampling areas, based on their geographical location Figure 2. Stations were fished at 3 depths (0, 4 and 7 m), and during the day and night. Most stations were fished on the flood tide because the scientific literature suggests glass eels utilise tidal stream transport to facilitate their migration through the estuary. However, if the vessel arrived at the sampling site before the tide had started to flood, limited sampling on the ebb tide was carried out.

In all, 1930 eels were captured in February-March and 334 in April 2103. This is in contrast to the 517 eels caught during the 2012 February-March survey. The data were explored visually by plotting the natural log of eel abundance for each fishing tow against a variety of explanatory variables, such as sampling depth and fishing site. In February 2012, the majority of the variables showed little or no apparent trend. However, for the explanatory variable Sampling Area, abundance appeared to be higher in the South. Similarly, abundance appeared to be highest at 0 m, when compared with 4 m and 7 m depth. In February 2013, again many of the plots showed little or no apparent trend, although for the variable Sampling Area, abundance in the Offshore area appeared lower than the other three areas, and again for the variable Depth, abundance appeared to be highest at the surface.

Ranking factor levels within explanatory variables on the basis of their mean eel abundance indicated that within the variable Site, the English Parallel and HPB sites consistently showed the highest mean eel abundances of all sites. The abundance of eels at the HPC site was consistently less than that of the HPB site and generally ranked in the middle of the 11 sites sampled. Eel abundance was consistently highest at the surface (0 m) than at deeper depths, and at lower salinities.

Non-parametric randomisation tests, which were used to determine whether there were statistically significant differences between the mean abundances of different factor levels within explanatory variables confirmed that in all three surveys, mean eel abundance was not significantly different between the English Parallel and HPB sites – the two sites closest inshore on the southern side of the estuary, but abundance at the English Parallel site was generally significantly higher than that observed at the HPC, Lilstock and Parrett sites – all of which lie further offshore.

These tests also confirmed that the abundance of eels at 7m depth was significantly less than that at both 4 m and 0 m depth in February 2012 and in April 2013. In February 2013, although mean abundance at 0 m depth was higher than both 4 m and 7 m depth, this was not statistically significant.

Repeating the survey in February 2013 and the addition of sampling in April 2013 provided information on variability in abundance both annually and within the recruitment season. The abundance in 2013 was approximately 3.5 times higher than in 2012.

In conclusion, the results of the surveys in 2012 and 2012 have confirmed that:

I. glass eels used the full width of the Severn Estuary to migrate upriver

II. The greatest abundance of eels was consistently found in shallow, inshore sites on the southern and northern sides of the Estuary.

III. There is evidence that eel densities are greater at the surface than at deeper depths; particularly than at depths of 7m

IV. The density of eels at the location of the proposed HPC intakes was significantly less than at further inshore sites.

The offshore location and depth of the HPC intakes would therefore mean that the abstracted cooling water would contain significantly less eels than water that might be taken from closer inshore and in shallower water.

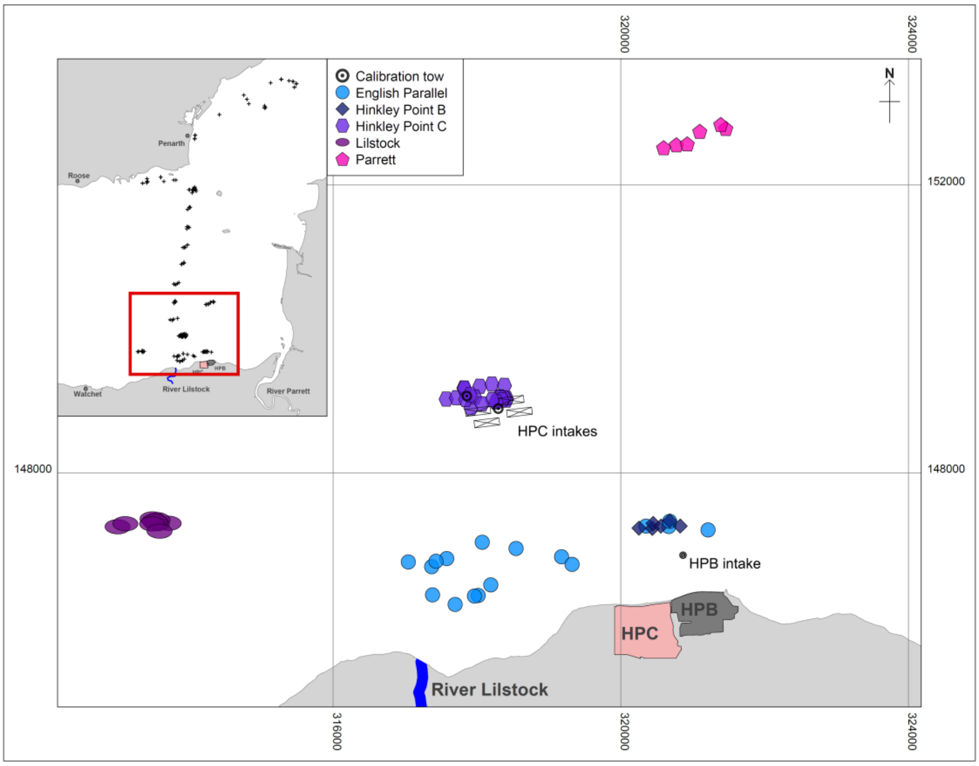


Figure 1 Map showing the locations of the fishing sites on the south side of the Severn estuary, and their proximity to the current Hinkley Point B and proposed Hinkley Point C intakes.

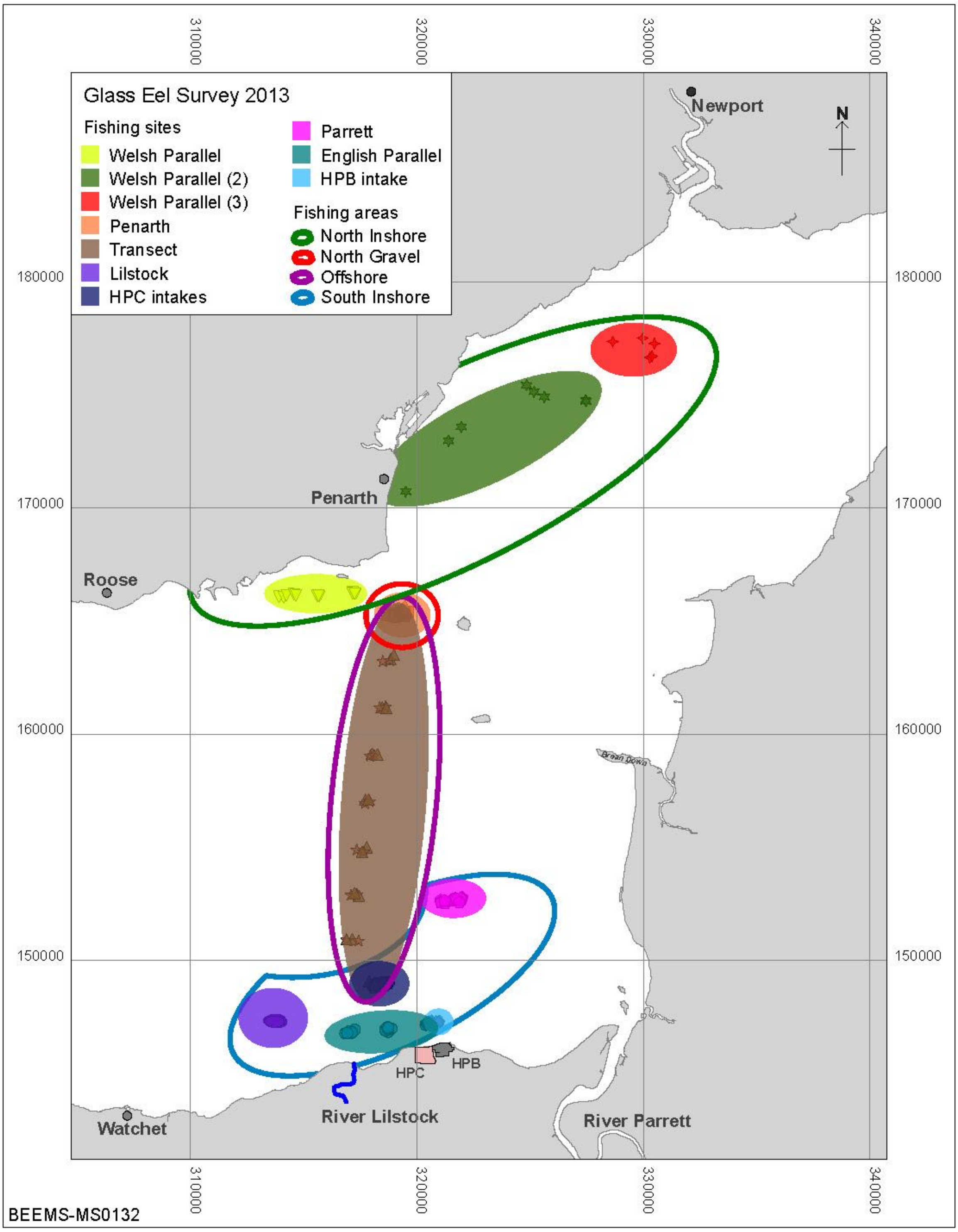


Figure 2 Map showing the locations of the fishing sites and their subsequent grouping into fishing areas

1 Background and purpose

The Severn Estuary is home to several fish species termed ‘conservation species’, *i.e.* species for which there is concern about their stock status. These species include the sea and river lampreys (*Petromyzon marinus* and *Lampetra fluviatilis*, respectively), the allis and twaite shad (*Alosa alosa* and *A. fallax*, respectively), and the European eel (*Anguilla anguilla*). All European eels belong to a single panmictic stock that is widely distributed in marine, coastal and freshwater habitats of Europe and occurs from the Atlantic coast of north Africa, through Europe, the Baltic Sea and in the Mediterranean waters of Europe and northern Africa (OSPAR, 2010). The species is listed as critically endangered in the IUCN Red List (Freyhof & Kottelat, 2010), is a UKBAP Priority species and has been included on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2010). The most recent ICES (International Council for the Exploration of the Sea) advice on the European eel is that the stock was still critical in 2012 (ICES, 2012).

To address the decline in eel stocks, the European Council has established an Eel Regulation (No 1100/2007), aimed at providing measures for recovery. The Regulation requires that all member states with natural eel habitats establish Eel Management Plans at the river basin level. The objective of these plans is to permit the escapement to the sea of at least 40% of the silver eel biomass, in order to spawn. The Regulation also requires that a control and monitoring system has to be set up by each member state. A review of the life history, stock status and management of the European eel is given in BEEMS Technical Report TR-S211.

Many factors can affect the migration of eels through estuaries, such as physical barriers, pollution, habitat loss and the impact of power station cooling systems (OSPAR, 2010). Eels are vulnerable to power station cooling water intakes by *impingement* (being retained on the drum screens) and *entrainment* (passing through the drum screens and then through the entire cooling water system) at different times during their life history. Yellow (immature) and silver eels (maturing adults that are heading downstream on their spawning migration) may be impinged on the drum screens that serve to prevent the passage of larger organisms through the cooling water system. Glass eels (of approximately 70-80 mm total length) may be entrained by the cooling water intakes, as they arrive from the Sargasso Sea and start their upward passage into freshwater.

Impingement data have been routinely collected at Hinkley Point ‘B’ (HPB) for over 30 years, providing information on the abundance of many species, including eels, at a fixed point in the Severn Estuary (BEEMS Technical Report TR-S251, 2012). These data indicate that the number of yellow eels impinged by the station has declined during the sampling period. Approximately 20-60 eels were caught annually during routine sampling in the early 1980s. However, in the last 5 years, this number has declined to around 1-5 yellow eels per year (Henderson et al., 2012).

Semi-quantitative zooplankton sampling is undertaken concurrently with the impingement monitoring at HPB, and has taken place at the site almost every month since 1988 (Plenty, 2012). A 150 μm mesh net is placed in the intake forebay for one hour per sampling visit, and the contents preserved and identified. The sampling is not strictly quantitative, as the volume of water filtered cannot be accurately determined, but the samples are believed to reflect the relative abundance of the fauna present at the time (Bamber & Henderson, 1994). Since 1988, 12 glass eels have been recorded in the monthly zooplankton samples, and all these individuals were caught in samples collected during February or March (Plenty, 2012).

Although these impingement and entrainment datasets provide information on the abundance of eels captured within the cooling water system of the HPB station, they do not provide information on the relative distribution or abundance of eels within the wider estuary. Knowledge of these is important in refining predictions of the impact of station-related mortality on the eel population.

To address this knowledge gap, BEEMS undertook a survey in 2012 to evaluate methods of sampling for glass eels in the Bristol Channel/Severn Estuary area in order to investigate the distribution and abundance of eels across the estuary. The survey was conducted over a 16-d period in February-March 2012, regarded as the beginning of the annual glass eel recruitment period that continues until around May-June (Defra, 2010). It was the first time that work of this type had been conducted in an estuary of this size.

While the survey provided preliminary information on the relative abundance and distribution of glass eels in the Severn Estuary/Bristol Channel, it was limited in that it represented only a single year of sampling. Consequently, the 2012 survey was repeated in February-March 2013. The aim of this second survey was to investigate whether the eels displayed similar spatial and vertical patterns of distribution to those observed in 2012, and to assess the temporal variability in abundance from year to year. A third survey was carried out in April 2013 to investigate changes in the abundance of eels within the same recruitment season.

2 Methodology

2.1 Field sampling methods

The survey methodology repeated that of the 2012 survey (BEEMS Technical Report TR-S211, 2012). The survey was conducted from a small (13.43 m) inshore commercial fishing vessel, the FV “Cerulean”, subcontracted from Talbot Trawlers Ltd. The first survey (denoted Hink 1/13) was conducted between 20 February and 3 March, and the second (Hink 2/13) between 5 April and 11 April 2013. During February 2013, tows were fished, as far as possible, at the same sites and in the same order as in 2012 (in 2013 the survey was only 14 days duration, compared to 16 days in 2012). The survey started on neap tides, continuing through spring tides to the subsequent neap tides. During April 2013, funds for an additional 7 days sampling were available for sampling and, to allow for comparisons between February and April, the survey dates were chosen to go from one neap tide to the next spring tide (*i.e*. to allow comparison with the first half of the February survey).

Sampling was carried out using a 1.4 m^2 Methot/Isaacs–Kidd (MIK) net (Methot, 1986) (Figure 3). The gear consists of a square frame which is towed from the vessel by warps attached to the sides of the frame, ensuring that the mouth of the net is clear of obstruction. The frame is held vertical in the water by the depressor, which hangs below the main frame. The net is constructed of 2-mm knotless mesh throughout, with a removable endbag to facilitate emptying the catch. Brackets on the top of the frame accommodate a CTD unit (to collect information on the physical environment), and a transponder beacon (to determine the depth of the top of the frame below the water surface). In order to determine the volume of water passing through the net during each tow, a flowmeter was attached across the mouth of the net.

In 2013, the Isaacs-Kidd ‘V’ shaped depressor was replaced by two Scripps depressors, each suspended by a short warp from the two bottom corners of the frame. These provided better stability of the gear in the water, keeping the net horizontal and making it easier and safer to manage during deployment and retrieval.

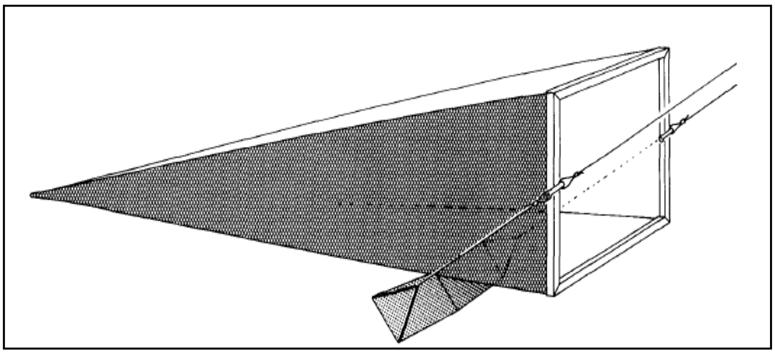


Figure 3 Line drawing of the Methot frame trawl with Isaacs-Kidd depressor (Methot, 1986) (left), Cefas-adapted MIK net frame ready for deployment at Hinkley Point (right), showing (A) PAM transponder beacon, (B) CTD unit and (C) General Oceanics flowmeter.

Sampling was conducted at several fishing sites within the Bristol Channel, with sites being designated by their locality or physical location (e.g. at the Hinkley Point ‘B’ intake site, denoted ‘Hinkley Point B’, or off the mouth of the River Parrett, denoted ‘Parrett’). In general, one fishing site was sampled each day and at each site, multiple tows (samples) were conducted by fishing at one of three depths – the surface (0 m), at 4 m and at 7 m, (i.e. the top of the frame was at this depth and sampled to 1.4 m below this depth). Sampling could not be conducted deeper than 7 m, because this would have risked the depressors or the frame snagging on the seabed. Each tow lasted for 15 minutes.

Sampling was also conducted along a transect line, composed of 9 fishing locations between Penarth in the north and the site of the proposed Hinkley Point 'C' intake in the south. In order to sample the transect line (which was approximately 10 miles long) in a single flood tide, one tow (or sample), was made at each fishing location, using a 'V'-shaped sampling profile. Rather than deploying the net to 0, 4 or 7 m and fishing at that depth for the full 15 minute period, the net was deployed and fished for 2.5 min at the surface, 2.5 min at 4 m depth, 5 min at 7 m depth, 2.5 min at 4 m depth and 2.5 min at the surface before being retrieved. This allowed the top 7 m of the water column to be sampled at each of the 9 transect locations on a single flood tide. The transect line was sampled from north to south and from south to north on separate days.

For all tows, the vessel was positioned into the oncoming tide and tow speed was kept as slow as possible, while retaining control. Sampling predominantly took place on the flooding tide, although if the vessel arrived at the sampling site before the tide had turned, some additional tows were fished on the ebb tide. Maps showing the actual locations of the tows fished within the designated sites in February-March and April 2013 are given in Figure 4 and Figure 5, respectively.

A global positioning system (GPS) data-logger linked directly to the Cefas Fishing Survey System database (FSS) recorded positional data for calculating distance towed. As a back-up, shot and haul position, time of day, the states of the tide and sea, depth and wind speed/direction and number of flow meter rotations during the tow, were recorded manually on sampling sheets.

Lengths for all eels captured were measured to the nearest mm, and all other fish species to the nearest 0.5 cm below, as per standard BEEMS sampling protocols (*i.e.* a fish measuring between 3.0 cm – 3.4 cm would be recorded as 3 cm, and a fish measuring 3.5 cm – 3.9 cm would be recorded as 3.5 cm). The presence of non-target organisms such as *Crangon crangon* was also noted. All organisms were returned to the water as quickly as possible, with the exception of a sample of eels that was retained during the April survey for determination of developmental stage.

Field reports for both surveys are included in Appendix A, and details on all fishing tows sampled are given in Appendix B.

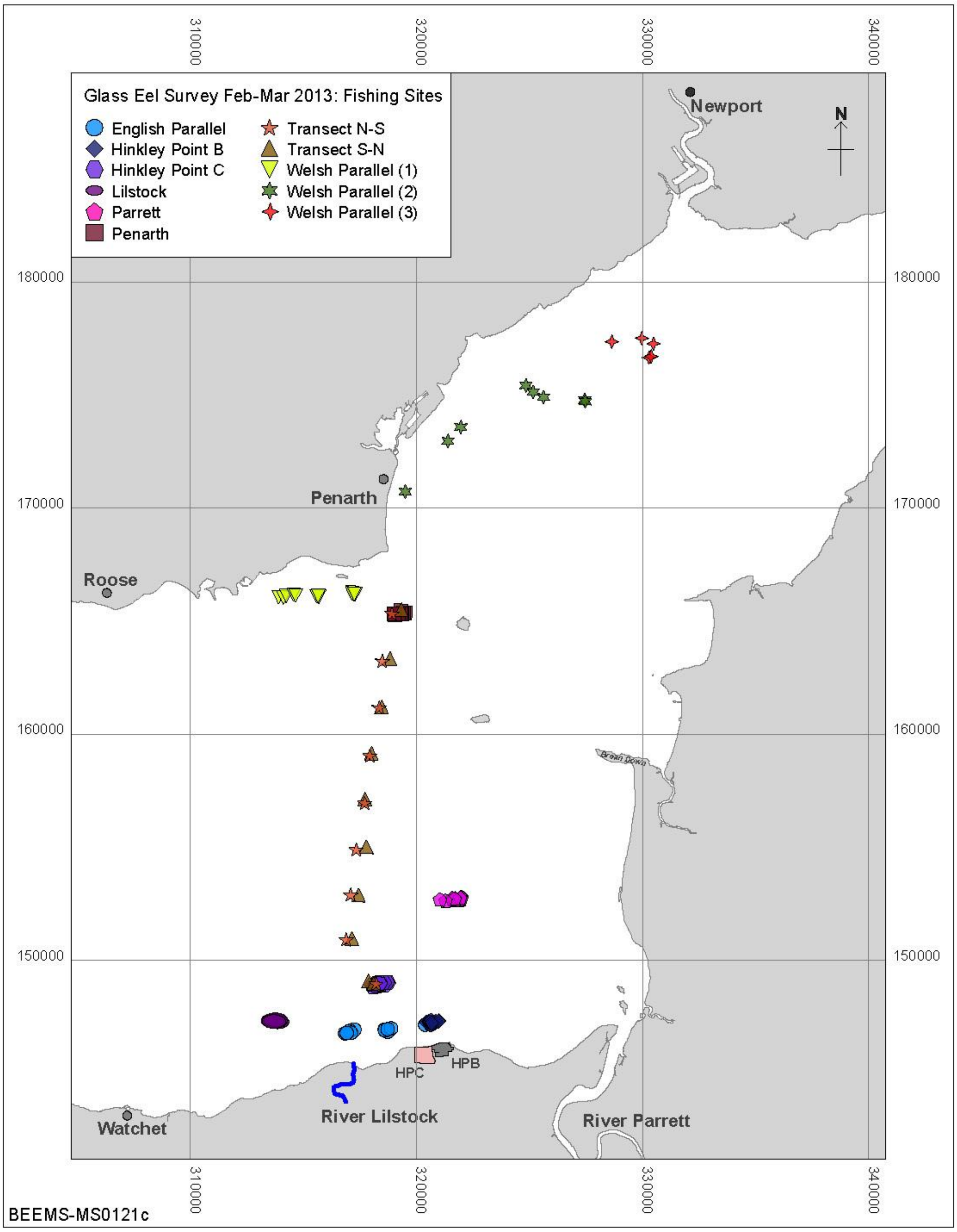


Figure 4 Position of all tows (samples) sampled during the February 2013 (Hink 1/13) glass eel survey, by their assigned fishing site.

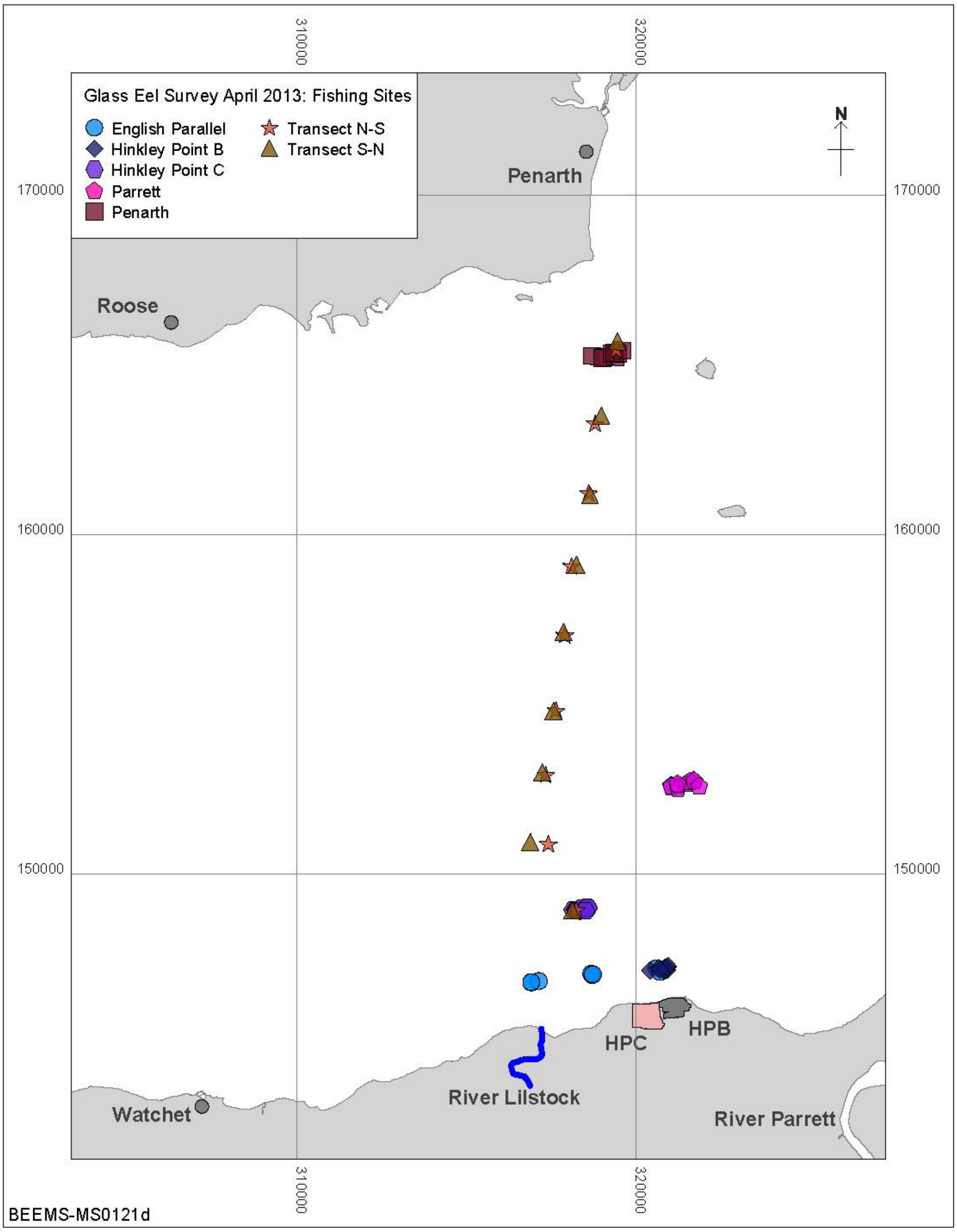


Figure 5 Position of all tows (samples) sampled during the 2013 (Hink 2/13) glass eel survey, by their assigned fishing site.

2.2 Determination of developmental stage

Eels that had been returned to the laboratory were defrosted, and their developmental stage assigned, based on the key given by Elie *et.al*. (1982). This key uses the degree and patterns of skin pigmentation to determine development. Each individual was weighed, and measured, before being preserved in 95% ethanol for long-term storage.

2.3 Data preparation and analysis

The physical data associated with the surveys, such as mean temperature and salinity (obtained from the CTD unit), and number of in-water flowmeter rotations, as well as catch data such as fish lengths and numbers and invertebrate counts were input into the Cefas FSS system and quality checked against the hard copy sheets by the Scientist in Charge and BEEMS Work Package 2 Data Manager. For each fishing tow, the flowmeter reading (number of revolutions completed while the unit was in the water) was converted to the volume of water filtered through the net (m^3), using the calculations provided in the manufacturer's (General Oceanics) manual. The number of eels caught in each tow was converted to abundance (expressed as number of fish per m^3 water filtered) using the total volume filtered:

$$Abundance = \frac{N}{V}$$

where:

N = Number of individuals sampled
V = Volume of water filtered (m^3)

Total eel abundance (number per m^3 water filtered) by tow is given in Appendix B.

Analyses were conducted on the 2012 data in addition to the 2013 datasets. This was because in 2012, the report (BEEMS Technical Report TR-S211) was required quickly as part of the DCO process, and only an indicative data analysis was carried out. However, in 2013, additional time allowed more extensive exploration of the data and it was decided to submit the 2012 data to the same analyses, to allow for direct comparison. In addition, in the 2012 dataset, one station had been inadvertently assigned to an incorrect sampling area (although it was assigned to the correct fishing site). This error was amended before the 2012 data were re-analysed, and the subsequent analysis indicated no change to the original conclusions.

2.3.1 Eel abundance

The influence of various physical and environmental variables on eel abundance was investigated for the surveys separately. The variables investigated are given in Table 1.

In 2012, the effect of these variables on eel abundance was investigated using Generalized Additive Models (GAMs). However, in the April 2013 data set there were many missing values for some of the explanatory variables (e.g. salinity and temperature) which caused imbalances and confounding in the model. Therefore, this approach could not be applied equally to all three datasets, and alternative methods of analysing the data were utilised.

Table 1 Description of the explanatory variables and factor levels investigated during data analysis

Variable	Description	Factor levels
Day since 1st Jan	The day, numbered from 1st January, when sampling took place	Continuous values
Hour	The hour of the day when sampling took place	Continuous values
Longitude	The longitudinal position where the gear was shot	Continuous values
Latitude	The latitudinal position where the gear was shot	Continuous values
Site	The locality in which fishing took place. Eleven sites were defined (see Figure 4 and Figure 5)	Penarth, Welsh Parallel 1, Welsh Parallel 2, Welsh Parallel 3, the North-South Transect, the South-North Transect, Parrett, Hinkley Point 'B', Hinkley Point 'C', Lilstock, and English Parallel
Area	Sites grouped into larger localities	North Gravel - Penarth North Inshore - Welsh Parallel 1, Welsh Parallel 2, Welsh Parallel 3 Offshore - the North-South Transect, the South-North Transect South Inshore - Parrett, Hinkley Point 'B', Hinkley Point 'C', Lilstock, and English Parallel
Depth	Depth at which fishing took place	0 m, 4 m, 7, m
Tide	Tidal state	Ebb, Flood, Slack
Time of day	Defined on the light levels	Day, Dusk, Dark
Temperature	Water temperature, determined using the CTD unit. Grouped by temperature range. The boundary points of the groups differed by survey due to different water temperatures in 2012 and 2013	February 2012 - ≤ 6.7 °C and > 6.7 °C February 2013 - ≤ 5.5 °C and > 5.5 °C April 2013 - ≤ 5.0 °C and > 5.0 °C
Salinity	Water salinity, determined using the CTD unit. Grouped by salinity	≤ 25.5 ‰ and >25.5 ‰

The data were first explored visually by plotting the *ln*+0.0001[1] of eel abundance for each fishing tow against each of the explanatory variables. In the case of the continuous variables (such as Day Number), these were plotted as scatter plots of observed abundance, while for variables for which factor levels were defined (such as Site or Depth), the mean abundance and confidence intervals were plotted against each factor level. The natural log (*ln*) was used to plot the data rather than absolute values because otherwise, many of the data points would be at the bottom of the plot, making it difficult to see patterns in the data. The *ln* abundance transformation 'pulls in' the high abundance values allowing better visualisation of the bulk of the data.

[1] 0.0001 was added to each abundance value before taking the natural log, to account for zeros in the catch data.

Mean abundance was then calculated for each of the explanatory variables with defined factor levels, (*i.e.* not the continuous variables). Factor levels were also created for two of the continuous variables (Temperature and Salinity), by placing the observations into one of two groups. For Salinity, these groups were water salinities of ≤ 25.5 ‰ and >25.5 ‰. For Temperature, the boundaries of the factor levels were different for the three surveys, as the water was notably colder in 2013 than in 2012. To provide consistency across the three surveys, mean abundance was calculated for samples collected on the flood tide only, and samples collected during the ebb or slack tide were excluded.

Each factor level within that explanatory variable was ranked on the basis of the resulting mean abundance value, with the factor level with the highest abundance given a ranking of 1. This ranking method allowed comparisons between surveys. For example, if a certain site was ranked as 1 in all three surveys then it suggested a consistency through time.

Next a nonparametric randomisation test (Manly, 1998) was used to determine whether there were statistically significant differences between the mean abundances of different factor levels within explanatory variables

2.3.2 Eel length distributions

Numbers at length were used to determine whether length distributions differed statistically significantly between variables. First, the mean, minimum and maximum length was calculated by factor level for the explanatory variables site, area, time of day, depth, salinity and temperature. The length distributions were compared using the empirical Cumulative Distribution Function (CDF - the proportion of the sample that is less than or equal to any particular length). CDFs were compared using the Kolmogorov-Smirnov test (Conover, 1971), which looks at the maximum difference in the CDF of the two distributions being compared (i.e. the maximum vertical difference from the CDF plots). Exact p-values for a two-sided test as described by (Marsaglia et al., 2003) in the R function *ks.test* were used.

3 Results

Totals of 130 and 63 tows, yielding 1930 and 334 eels were sampled in February and April 2013, respectively. This is in contrast to the 517 eels caught in 128 tows during the February 2012 survey.

In February 2012, the majority (approximately 85%) of the 128 fishing tows sampled contained 5 eels or less (Appendix C), and the highest number of eels caught in any one tow was 43 individuals. In contrast, in February 2013, approximately 75% of the 130 fishing tows sampled contained 6 or more individuals. The highest number of eels observed in one fishing tow was 125, which were caught near the Welsh side of the estuary, at the surface, at night, on a flood tide. In April 2013, approximately 63% of fishing tows sampled contained 5 eels or less.

3.1 Eel abundance

Plots of *ln*(eel abundance +0.0001) versus each explanatory variable are given for the three surveys in Appendix D. In February 2012, the majority of the variables showed little or no apparent trend in *ln*(abundance). However, for the variable Area, *ln*(abundance) appeared to be higher in the South (Sou) category. Similarly, *ln*(abundance) appeared to be highest at 0 m in the Depth variable. In February 2013, again many of the plots showed little or no apparent trend, although for Area, *ln*(abundance) in the Offshore (Off) area appeared lower than the other three areas, and again for Depth, *ln*(abundance) appeared highest at the surface.

The mean abundances of each factor level within the explanatory variables are given in Table 2 for February 2012, February 2013 and April 2013. Within the variable Site, the English Parallel and HPB sites had mean abundances that were ranked in the top three in all three surveys. The HPC site was generally ranked in the middle of the 11 sites sampled. Eel abundance was consistently highest at the surface (0 m) than at deeper depths, and in the lower salinity group. There appeared to be no clear trend as a result of the Area, Time of Day or temperature.

The results of selected paired randomisation tests are given in Table 3. For the February 2012 survey, this analysis appears to confirm the difference in eel abundance between samples from 7m depth and those at both 4 m and 0 m depth (significantly less eels were caught at 7 m; p = 0.03 in both comparisons). In terms of sampling Area, significantly less eels were caught in the Offshore Area than the South Bank inshore area (p = 0.02). Although the mean abundance of eels in the North Gravel area was the lowest of the 4 areas (mean = 6.2×10^{-4} eels m^{-3}), a statistical difference between this and the other 3 sites could not be shown, almost certainly because of the low sample size.

Comparing between individual sites, the mean abundance at the English Parallel site was not significantly different to the HPB site, but was significantly higher than at the HPC, Lilstock and Parrett sites on the English side, the two transects across the estuary and the Welsh Parallel 1 and Welsh parallel 3 sites. (Table 3). Both temperature and salinity showed significant difference between the two groups defined, with significantly ($p < 0.001$) more eels at low salinity and high temperatures

In February 2013, again, abundance in the South Bank inshore area was significantly higher than that seen in the Offshore area ($p < 0.001$). Although mean abundance at 0 m depth was higher than both 4 m and 7 m depth, this was not statistically significant. Comparing between individual sites, again the mean abundance at the English Parallel site did not differ significantly with the HPB site, but was significantly higher than the three other English sites (HPC, Lilstock and Parrett). (Table 3). In contrast to February 2012, eel abundance was significantly higher at low temperatures than high temperatures.

In April 2013 the highest abundance of eels was at the surface, and in comparison with abundance at 7 m depth, this difference was statistically significant. As in 2012, highest eel abundance was observed at higher temperatures and lower salinities, despite the temperature range in April 2013 being more similar to that of February 2013 than to February 2012. Abundance at the English parallel site was again the highest of the sites and was significantly higher than at HPC or Parrett sites.

Table 2 Mean eel abundance (x10^{-4} eels m^{-3} water filtered) for factor levels within explanatory variables. The number of tows sampled in each category is given in brackets. Each factor level is ranked within its explanatory variable, with highest mean abundance assigned a rank of 1. Note that for temperature, three different groupings were used for the three surveys. The groupings and their respective means are reflected by the different coloured text. Only samples collected on the flood tide were included in the analysis

Explanatory Variable	Factor level	February-March 2012		February-March 2013		April 2013	
		Mean (no of tows)	Rank	Mean (no of tows)	Rank	Mean (no of tows)	Rank
Area	North Gravel	6.2 (9)	4	61.4 (7)	3	33.1 (9)	1
	North Inshore	14.3 (21)	2	69.5 (20)	1	-	-
	Offshore	10.2 (36)	3	20.0 (18)	4	15.6 (18)	3
	South Inshore	24.2 (56)	1	63.1 (70)	2	21.9 (36)	2
Site	English Parallel	52.8 (14)	1	87.0 (17)	2	37.2 (8)	1
	Hinkley B	29.9 (6)	2	70.3 (15)	3	27.8 (9)	3
	Hinkley C	11.3 (21)	6	55.6 (21)	5	11.0 (9)	7
	Lilstock	15.8 (9)	4	52.5 (8)	7	-	-
	Parrett	9.6 (6)	8	32.9 (9)	8	14.0 (10)	6
	Penarth	6.2 (9)	11	61.4 (7)	4	33.1 (9)	2
	Transect N-S	7.8 (9)	9	12.7 (9)	11	14.2 (9)	5
	Transect S-N	11.0 (27)	7	27.3 (9)	9	16.9 (9)	4
	Welsh Parallel (1)	6.8 (9)	10	23.4 (9)	10	-	-
	Welsh Parallel (2)	24.0 (7)	3	53.8 (6)	6	-	-
	Welsh Parallel (3)	14.1 (5)	5	171.2 (5)	1	-	-
Depth	0 m	24.2 (60)	1	77.6 (45)	1	34.8 (15)	1
	4 m	13.2 (22)	2	51.6 (29)	3	21.8 (15)	2
	7 m	7.0 (13)	3	54.3 (23)	2	15.7 (15)	3
Time of day	Dark	14.7 (40)	3	82.4 (39)	1	-	-
	Dusk	25.7 (15)	1	50.9 (13)	2	-	-
	Light	16.5 (67)	2	43.2 (63)	3	21.7 (63)	1
Salinity	≤ 25.5	27.4 (44)	1	71.8 (45)	1	49.3 (9)	1
	>25.5	11.5 (51)	2	50.4 (54)	2	13.4 (37)	2
Temperature	≤ 6.7, ≤ 5.5, ≤ 5.0	9.9 (48)	2	81.4 (50)	1	13.8 (22)	1
	> 6.7, > 5.5, > 5.0	28.1 (47)	1	38.5 (49)	2	26.5 (24)	2

Table 3 p-values of selected randomisation t-test comparisons between factor levels within explanatory variables. Significant differences between pairs are indicated using red text

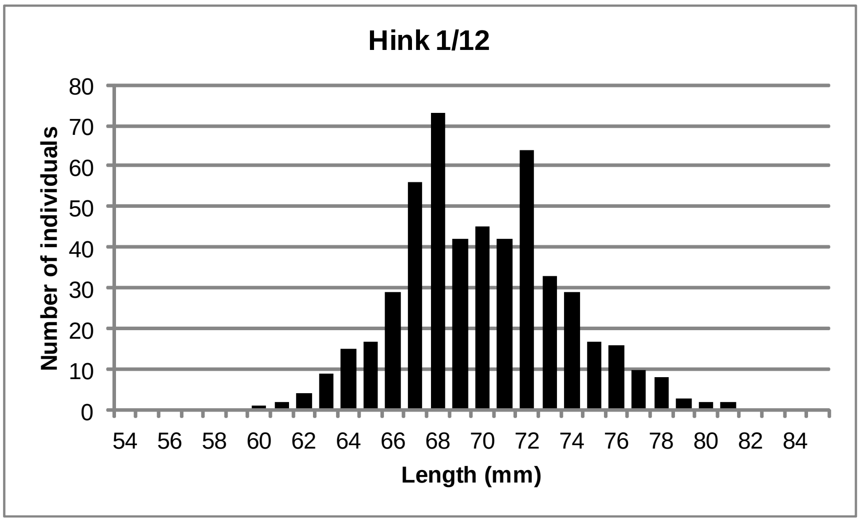
Comparison	February-March 2012	February-March 2013	April 2013
Area			
North Bank Gravel v North Bank inshore	0.15	0.86	-
South Bank inshore v Offshore	0.002	< 0.001	0.28
South Bank inshore v North Bank inshore	0.14	0.69	-
Site			
English Parallel v Hinkley Point B	0.24	0.34	0.5
English Parallel v Hinkley Point C	<0.001	0.004	0.005
English Parallel v Lilstock	0.01	0.07	-
English Parallel v Parrett	0.02	<0.001	0.005
English Parallel v Penarth	0.001	0.13	0.73
English Parallel v Transect N-S	0.004	<0.001	0.05
English Parallel v Transect S-N	<0.001	<0.001	0.02
English Parallel v Welsh Parallel (1)	0.002	<0.001	-
English Parallel v Welsh Parallel (2)	0.11	0.08	-
English Parallel v Welsh Parallel (3)	0.06	0.07	-
Hinkley Point C v Hinkley Point B	0.007	0.33	0.17
Hinkley Point C v English Parallel	< 0.001	0.004	0.005
Hinkley Point C v Lilstock	0.16	0.84	-
Hinkley Point C v Parrett	0.66	0.03	0.41
Hinkley Point C v Penarth	0.1	0.65	0.01
Hinkley Point C v Transect N-S	0.29	0.008	0.34
Hinkley Point C v Transect S-N	0.92	<0.001	0.46
Hinkley Point C v Welsh Parallel (1)	0.17	0.005	-
Hinkley Point C v Welsh Parallel (2)	0.04	0.89	-
Hinkley Point C v Welsh Parallel (3)	0.48	0.006	-
Depth			
Depth = 7 v Depth = 4	0.03	0.79	0.36
Depth = 7 v Depth = 0	0.03	0.18	0.03
Time of day			
Day v Dark	0.6	<0.001	-
Day v Dusk	0.19	0.55	-
Salinity (‰)			
Salinity ≤ 25.5 v Salinity > 25.5	<0.001	0.07	<0.001
Temperature (°C)			
Temp ≤ 6.7 v Temp > 6.7	<0.001		
Temp ≤ 5.5 v Temp > 5.5		<0.001	
Temp ≤ 5.0 v Temp > 5.0			0.03

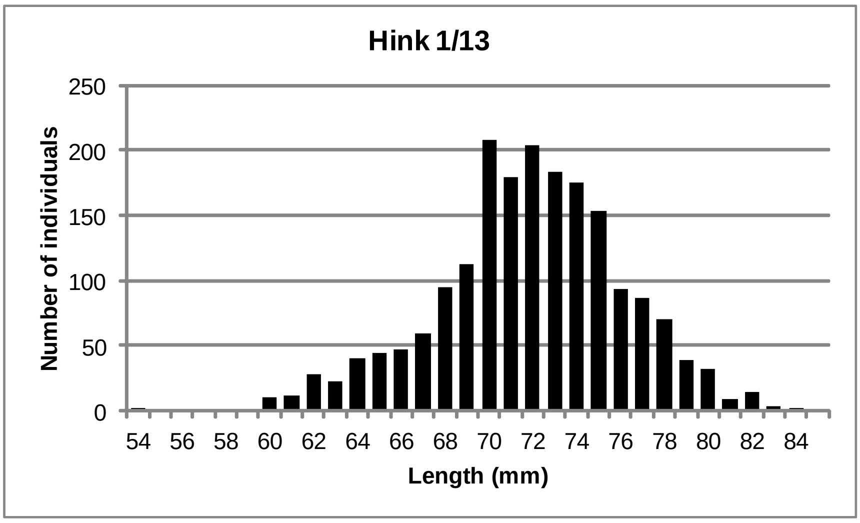
3.2 Eel length distribution

Length distributions for the three surveys are shown in Figure 6. The length distributions were unimodal for all three surveys, suggesting the recruitment of a single cohort. Length ranged between 60 – 81 mm, 55 – 84 mm and 60 – 85 mm for February-March 2012, February-March 2013 and April 2013, respectively. The summary statistics of mean, minimum and maximum length by factor level, and plots of mean length by site and depth are given in Appendix E. There appear to be no consistent trends in mean size by fishing site or depth in any of the three surveys.

Cumulative Distribution Functions (CDFs), which show the proportion of the length distribution that is less than or equal to any particular length, are given by site, area, time of day, depth, salinity and temperature in Appendix E.3 – E.5 for February-March 2012, February-March 2013 and April 2013, respectively. Selected results (*p*-values) of the paired Kolmogorov tests, which compared the CDFs, are given in Table 4. Significant differences between pairs are indicated using red text.

Within the variables examined, there was no consistent pattern of differences between the length distributions. For example, within the explanatory variable Area, significant differences were seen between the South Bank Inshore and Offshore length distributions in February 2012 and February 2013. However, in 2012, the individuals caught offshore were larger than those caught inshore. Conversely those caught inshore in 2013, were larger than those caught offshore. Similarly, individuals caught at HPC were not consistently different in size to individuals caught at any other site.





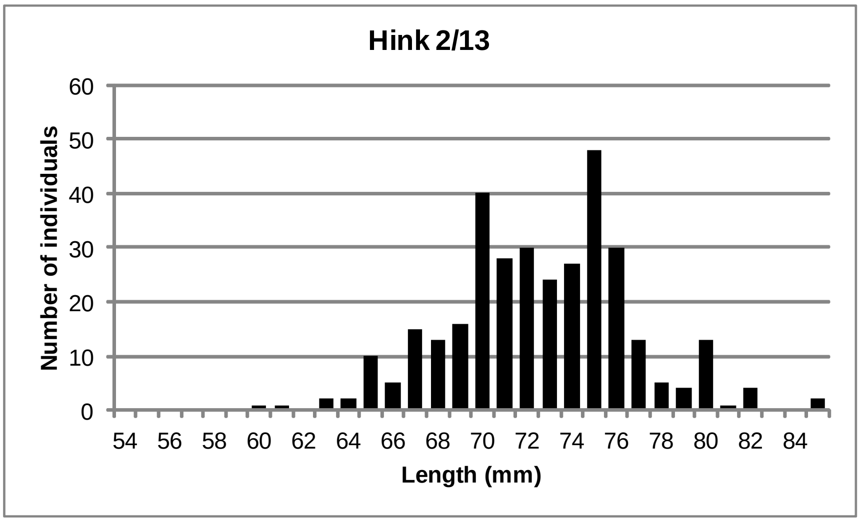


Figure 6 Length distributions for eels caught during February 2012 (Hink 1/12), February 2013 (Hink 1/13) and April 2013 (Hink 2/13).

Table 4 p-values from Kolmogorov-Smirnov tests comparing the CDFs of eels by area, site, depth, time of day, salinity and temperature for all three surveys. Significant differences between pairs are indicated using red text

Comparison	February - March 2012	February - March 2013	April 2013
Area			
North Bank Gravel v North Bank inshore	0.19	<0.001	-
South Bank inshore v Offshore	<0.001	<0.001	0.44
South Bank inshore v North Bank inshore	0.15	<0.001	-
Sites			
English Parallel v Hinkley Point B	0.41	0.001	0.21
English Parallel v Hinkley Point C	0.006	<0.001	0.59
English Parallel v Lilstock	0.008	<0.001	-
English Parallel v Parrett	0.76	0.03	0.56
English Parallel v Penarth	0.23	0.004	0.99
English Parallel v Transect N-S	0.02	0.001	0.96
English Parallel v Transect S-N	<0.001	0.02	0.69
English Parallel v Welsh Parallel (1)	0.38	<0.001	-
English Parallel v Welsh Parallel (2)	0.47	0.28	-
English Parallel v Welsh Parallel (3)	0.83	0.15	-
Hinkley Point C v Hinkley Point B	0.57	0.18	0.21
Hinkley Point C v English Parallel	0.006	<0.001	0.59
Hinkley Point C v Lilstock	0.72	0.16	-
Hinkley Point C v Parrett	0.74	0.42	0.95
Hinkley Point C v Penarth	0.85	<0.001	0.84
Hinkley Point C v Transect N-S	0.24	<0.001	0.78
Hinkley Point C v Transect S-N	0.4	0.89	0.24
Hinkley Point C v Welsh Parallel (1)	0.87	<0.001	-
Hinkley Point C v Welsh Parallel (2)	0.04	0.03	-
Hinkley Point C v Welsh Parallel (3)	0.11	<0.001	-
Depth (m)			
Depth = 7 v Depth = 4	0.34	0.73	0.4
Depth = 7 v Depth = 0	0.014	0.03	0.4
Time of day			
Day v Dark	0.64	<0.001	-
Day v Dusk	0.11	0.03	-
Salinity (‰)			
Salinity ≤ 25.5 v Salinity > 25.5	<0.001	0.43	0.02
Temperature (°C)			
Temp ≤ 6.7 v Temp > 6.7	0.002		
Temp ≤ 5.5 v Temp > 5.5		<0.001	
Temp ≤ 5.0 v Temp > 5.0			0.07

3.3 Eel life history stages

A total of 180 eels were retained for determination of their life history stage during the April 2013 survey. A further 111 eels was retained in February 2012, but determination of their developmental stages could not be completed by the required delivery date of the report for that survey (BEEMS Technical Report TR-S211). They are therefore reported here. No eels were retained during the February 2013 survey. A full description of the developmental stages is given in Appendix F.

Eel leptocephali metamorphose into glass eels when they reach the continental slope, and at approximately 70-80 mm total length. There follows a period of pigmentation, that is believed to depend on temperature and salinity. During the early part of the pigmentation phase, glass eels do not feed, and feeding most frequently recommences when individuals are at the VI_{A2} stage (Adam et al., 2008). Full pigmentation and the end of the glass eel stage are marked by stage VI_{B}. Stage VII (yellow eel) is characterised by the appearance of yellow pigments and an increasingly benthic behaviour.

In 2012, all but two of the eels assessed were assigned to the Vb stage (Table 5). The other two eels were assigned to the VI_{A0} stage. In 2013, again the majority (94.4 %) of individuals were in the Vb stage, spanning the entire length range (63 – 82 mm TL). Nine individuals (71 – 76 mm TL) were classed as stage VI_{A0} and one individual (80 mm TL) as VI_{A1}. These results and the dominance of individuals at stage Vb is unsurprising, as it is reported that it is at these stages that elvers are the most abundant in salt- and fresh-water estuaries and the stage at which they are fished (Adam et al., 2008).

Table 5 Life history stages of eels retained during the February 2012 and April 2013 surveys, based on the classification of Elie et al. (1982).

	February 2012			April 2013			
Length (mm)	Vb	VI_{A0}	Total	Vb	VI_{A0}	VI_{A1}	Total
62	1		1				
63	3		3	1			1
64	8		8	1			1
65	3		3	7			7
66	9		9	4			4
67	10		10	9			9
68	17		17	7			7
69	5		5	8			8
70	12	1	13	20			20
71	4	1	5	12	1		13
72	11		11	20			20
73	11		11	16	1		17
74	5		5	10	2		12
75	4		4	23	4		27
76	1		1	13	1		14
77	1		1	5			5
78	1		1	2			2
79				2			2
80	1		1	7		1	8
81	2		2	1			1
82				2			2
Total	109	2	111	170	9	1	180

4 Synthesis

In February 2012, WP2 of BEEMS undertook a survey to trial methods for sampling of glass eels in a large estuarine environment (Bristol Channel/ Severn Estuary), and to provide data on glass eel abundance and distribution in the area. The main aim of the survey was to assess the potential entrainment risk and impact of the proposed HPC site on glass eels as they pass through the estuary. Results indicated that, although the glass eels were distributed through the whole estuary, relatively more eels were distributed in surface waters, on the English side of the estuary in shallow waters. As a consequence of these results, it was concluded that the potential entrainment risk of the cooling water intakes of HPC (which will be situated further offshore in deeper water) was minimal. However, the preliminary study recognized that sampling was limited in terms of the time of year during which sampling took place (the start of the recruitment period), the number of stations sampled and by the fact that it represented one year of data only.

A second survey, conducted in February-March 2013 aimed to validate, if possible, the patterns of relative distribution and abundance observed in 2012, and to provide information on annual variability in the numbers of eels passing through the estuary. The survey was completed at the same time of year, on the same stage of the lunar cycle, and using the same vessel and (slightly modified) gear as utilized in 2012, in order to retain as much consistency between surveys as possible. A third survey was undertaken in April 2013 to investigate changes in eel abundance within a recruitment season. This survey sampled on the same part of the tidal cycle as the first 7 days of the February surveys.

In all, 130 and 63 tows, yielding 1930 and 334 eels were sampled in February and April 2103, respectively. This is in contrast to the 517 eels caught in 128 tows during the February 2012 survey. As in 2012, glass eels used the full width of the Severn Estuary to migrate with greatest abundances found in the southern and northern inshore areas. Abundances at the HPC site were generally ranked in the middle of the sites sampled. Individual paired comparisons using non-parametric randomization tests to compare pairs of mean eel abundance showed that the mean abundance of the eels at the more inshore English Parallel site was significantly higher than at HPC in all three surveys. Samples taken at the surface always showed higher mean abundances than those from 4 and 7 m, though these differences were not always statistically significant. Similarly, samples taken in water of lower salinity always showed higher mean abundance than sites of higher salinity. The offshore location and depth of the HPC intakes would therefore mean that cooling water will contain significantly less eels than water that might be taken from closer inshore and in shallower water.

Repeating the survey in February in 2013 provided important information on changes in relative abundance from year to year. Almost three times as many eels were observed in February 2013, compared to February 2012. The overall mean abundance for all tows sampled in 2012 was 0.001711 eels m^{-3} (95% CI = 0.00383 eels m^{-3}), compared with 0.00580 eels m^{-3} (95% CI = 0.00103 eels m^{-3}) in 2013. From just 2 sampling years it is not possible to conclude whether 2012 represented a poor year or that 2013 represented a particularly good year for eel recruitment, although the Joint EIFAA/ICES ICES Working Group on Eels reports that the estimate of relative recruitment for Europe (excluding the North Sea) in 2013 was notably higher than that recorded in the previous 5 years. However, the 5-year average from 2008-2013 was still significantly lower than the long-term time series. Anecdotal information from French and Spain glass eel fisheries suggested that fishery catches in early 2013 were good relative to those in 2012.

The addition of the third survey in April 2013 also provided information on changes in abundance within a single recruitment season. This is important because recruits enter the estuary in pulses when variations in local physical conditions (such as water temperature and salinity) can bring forward or delay the passage of individuals into freshwater. The overall mean abundance for all tows sampled in the first 7 days of the February 2013 survey (0.00393 eels m^{-3}; CI = 0.00077 eels m^{-3}) was higher than the overall mean abundance of all tows sampled during the 7 days in April 2013 (0.00216 eels m^{-3}; CI = 0.00052 eels m^{-3}), providing an initial indication of the scale of changes in abundance. This could allow the calculation of a mean abundance through the recruitment season.

5 Conclusions

The results of the surveys in 2012 and 2012 have confirmed that:

V. glass eels used the full width of the Severn Estuary to migrate upriver.

VI. The greatest abundance of eels was consistently found in shallow, inshore sites on the southern and northern sides of the Estuary.

VII. There is evidence that eel densities are greater at the surface than at deeper depths; particularly than at depths of 7m

VIII. The density of eels at the location of the proposed HPC intakes was significantly less than at further inshore sites.

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Appendix A Survey field reports

A.1 February 2013 (Hink 1/13)

CENTRE FOR ENVIRONMENT, FISHERIES AND AQUACULTURE SCIENCE, LOWESTOFT LABORATORY, LOWESTOFT, SUFFOLK NR33 OHT

BEEMS CONTRACT. WP2 NEARSHORE 2013 SURVEYS

HINKLEY POINT: SITE C

REPORT: MFV Cerulean cruise 1/13

SKIPPER: J Richards

CEFAS STAFF: R Bush (19 February - 4 March) SIC
A Pliru (19 - 22 February 2013)
O Williams (22 – 26 February 2013)
P Bouch (27 February – 4 March 2013)

DURATION: 19 February–4 March 2013

LOCATION: Hinkley Point

AIMS:

1. Determine the abundance and distribution of glass eels across the Severn estuary between Lilstock on the North Devon coast, and Swanbridge on the South Wales coast.

2. Determine the abundance and distribution of glass eels in the vicinity of the current Hinkley Point ‘B’ intakes and the intakes of the proposed Hinkley ‘C’ new nuclear build and investigate the effect of depth, salinity, and tidal state on eel abundance.

NARRATIVE:

Having travelled down to Cardiff the previous day Cefas staff met with the FV Cerulean at 0900h on 19th February whereupon the gear was unloaded and the MIK net assembled. After consulting with the skipper it was decided to fish the evening tide. The Cerulean left port in calm weather at 1500h and headed south to the proposed Hinkley ‘C’ area. A total of 10, fifteen minute tows were successfully fished at alternating depths of; 0, 4 and 7 metres, with 3 tows fished on the ebb and 7 fished on the flooding tide. A total of 133 eels were caught, with one tow producing 23 eels. Other species present in the catch were sprat, whiting, sea lamprey and sand gobies. Cerulean returned to port at 0230h, and after looking at the forecast it was decided that sampling should be switched to the morning tide for the following day’s fishing.

FV Cerulean departed Penarth at 0730h. The vessel made for the northernmost transect site to conduct the transect in a southwards fashion. The wind had increased to force 4-5 from the NE, resulting in a marked temperature drop and severe wind chill. A total of 9 tows were fished along the transect, yielding 17 eels, 12 of which came from the first tow, (transect 9, located near the proposed ‘C’ intake). For each transect tow, the gear was fished in a ‘V’ profile, at 2.5 minutes on the surface, 2.5 minutes at 4m depth, 5 minutes at 7m depth, 2.5 minutes at 4m depth and 2.5 minutes on the surface in order to provide as great a sampling coverage as possible. Cerulean returned to port at 1700h.

Over the next two days, Thursday 21st and Friday 22nd, a total of 17 stations were fished in the vicinity of Lilstock to the west of the proposed intakes and at the current Hinkley Point ‘B’ intake. One hundred and nine eels were caught at the Lilstock site, with one tow producing 45 individuals. The first tow at Hinkley Point ‘B’ intake resulted in a torn belly so the net was changed and the day continued with no further incidents, and producing 89 eels. The wind was still coming from the NE with a considerable wind chill and the air temperature was recorded at 1.5°C by the CTD fixed on the net.

On Saturday 23rd a planned staff changed occurred with Antonio Pliru returning to Lowestoft and Oliver Williams joining the boat. Saturday 23rd and Sunday 24th saw the completion of the English sites of the survey, fishing the Parret and English parallel sites and completing 13 and 9 successful stations, respectively. A total of 268 eels were caught during the two days taking the overall total to 617.

On Monday 25th Cerulean departed Penarth at 1000h and proceeded to the Welsh parallel 1 site, west of Penarth and conducted 12 tows, two on the ebb and 10 on the flood. In total 87 eels were caught. It was noted by the skipper that the tides had increased significantly over the week and that at this site the tide was so strong he was having an issue making any headway whilst towing. The Cerulean returned to Penarth at 1930h that evening.

Cerulean departed Penarth at 1100h on February 26th, and headed south to the Penarth stations. A total of 9 stations were fished 3 on the ebb and six on the flood. The day was cut short when it was noticed that the CTD had suffered a severe crack along it’s casing and no recording lights were showing. Even with a reduced day 144 eels were caught and in the last tow of the day, a surprise Lumpsucker, *Cyclopterus lumpus* was caught. The Cerulean docked back at Penarth around 2000h. Another staff change took place with Oliver Williams returning to Lowestoft and Paul Bouch joining the vessel.

Over the next three days the transect was fished from north to south, along with the Welsh parallel 2 & 3 sites. The last two sites proved some what troublesome as they were very shallow and the tides were at their largest. It meant having to pass through the Cardiff lock early, so that we had enough water to do so, but then wait for the tide to turn and flood and allow us safe fishing. Twenty-two tows were however successfully fished with 423 eels caught. The best tow was the last one fished at Welsh parallel 3, which was fished in full dark and which yielded 125 eels for a 15 minute tow on the surface. This completed the Welsh side of the survey.

On Saturday 2nd March Cerulean departed Penarth at 1300h and headed south to repeat tows conducted at Hinkley Point ‘B’ intake. The weather had improved over the week and the wind had dropped to force 2-3, still from the NE but with far less wind chill, making it far more pleasant. Twelve tows were successfully fished. However, due to insufficient water depth, it was not possible to fish at 7m depth until the end of the sampling period. These stations were fished from full daylight, through to dusk and full night. Catches totalled 156 with the numbers of eel being caught increasing markedly during dark and when fished at 7m. On the way back to port, one tow was

fished just outside the barrage, as part of Welsh parallel 3 with six eels being caught taking the total of the day to 162. The Cerulean docked in Penarth around 2300h.
On March 3rd 8 stations at English parallel site were repeated. As the tides were at the springs part of the lunar cycle, there was not sufficient water to carry out the full three repetitions of tows at 0, 4 and 7m depth. Therefore 8 successful tows were completed; 4 at 0m and 2 each at 4 and 7m, before the tide turned. Catches steadily increased over the night with a total of 222 eels being caught. The Cerulean returned to Penarth and docked around 2345h.

For the last day of sampling, 4th March, the Cerulean left Penarth at around 1330h and headed south to repeat the tows of the proposed Hinkley 'C' intake site. Three tows were initially fished over the ebb tide at 0m, and this yielded a somewhat surprising 116 eels. Over the flood tide a further 7 tows were conducted and 156 eels caught. As with the other sites the insufficient water resulted in a reduced number of tows at 4 and 7m. With all surveying complete the Cerulean headed back to Penarth docking at 2300h, where upon all survey gear was unloaded of the boat and the boat and crew headed back to Bideford. Cefas staff travelled back to Lowestoft the following day on March 5th.

RESULTS:

1) A total of 130 valid stations was completed during the survey. One station was invalid due to gear damage, in the vicinity of Hinkley 'B' intakes. A breakdown of the number of stations, by sampling location and time of day is given in Table 1. Station positions are plotted in Figure 1.

2) A total of 1930 eels were caught during the survey, ranging in size from 54-84mm (Figure 2). Figure 3 shows eel lengths as caught in English and Welsh stations.

3) A total of 24 other finfish species were caught and measured to the nearest half cm (Table 2).

4) Eels were distributed across the entire estuary when sampling using the 'V' profile (Table 3). By number, more fish were caught in the southernmost transect sites, but whether abundance was significantly higher in these sites has yet to be investigated statistically.

5) Eels were distributed in the vicinity of the current Hinkley Point 'B' station intakes, the proposed Hinkley Point 'C' intakes (which are further offshore), off Lilstock to the west and off the River Parrett further east. In this area, the estuary bottom slopes away gently and the sediment is muddy and sandy.

6) Eels were also found on the Welsh side of the Bristol Channel, with total numbers caught roughly a third (598) of the total number caught (1930). It was noted that the largest single catch of 125 was on a Welsh station.

7) Eels were most abundant in tows conducted at the surface (Table 4). Abundance appeared to increase marginally during the night (Table 5), but again, this has not yet been tested statistically.

Our thanks go to the skipper and crew of the FV Cerulean for their hard work in making the survey successful

R Bush 7 March 2013

Table 1. Number of stations sampled during the Hink 1/13 survey

Station	Daylight	Dusk	Darkness	Total
Valid tows				
Hinkley Point B	10	2	6	18
Hinkley Point C	3	3	15	21
Lilstock	9			9
Parret	13			13
English Parallel	7	5	5	17
Penarth	6	2		8
Transect N-S	9			9
Transect S-N	5	3	2	10
Welsh Parallel	8	4		12
Welsh Parallel (2)			8	8
Welsh Parallel (3)			5	5
				0
Invalid tows				0
Hinkley Point B	1			1
	76	14	41	131

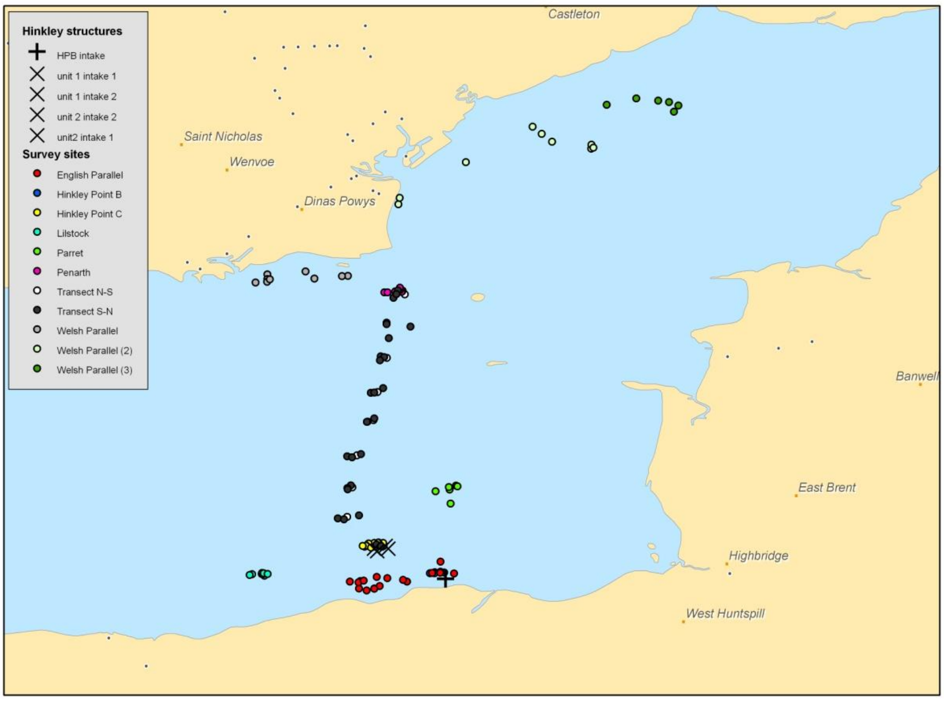


Figure 1. Position of all stations fished during the Hink 1/13 survey, by survey site

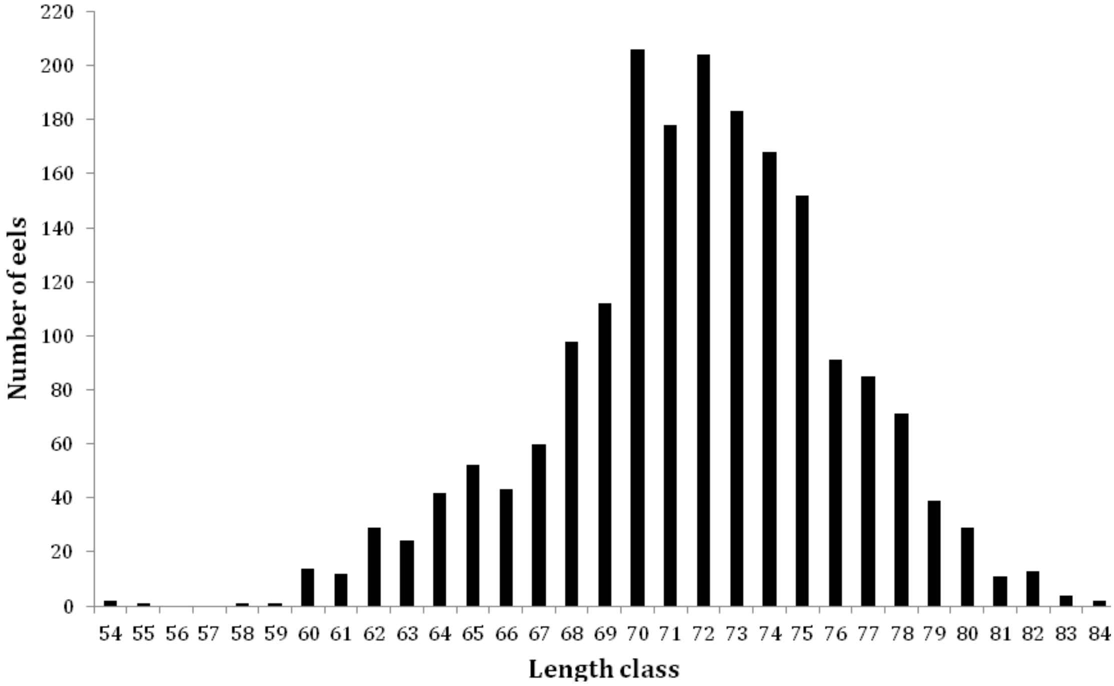


Figure 2. Length distribution of all eels caught during Hink 1/13

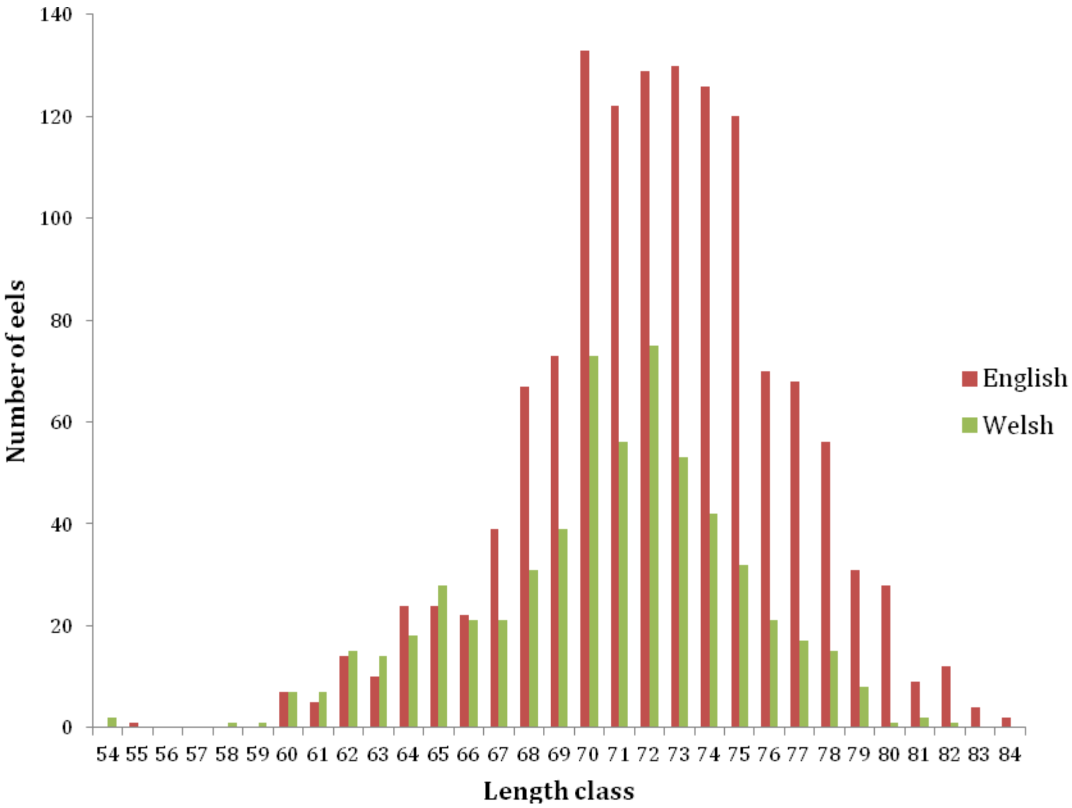


Figure 3. Length distribution of eels caught in English and Welsh stations during Hink 1/13.

Table 2. Total numbers of fish captured during Hink 1/13

Species	Number
European eel *Anguilla anguilla*	1930
Sprat *Sprattus sprattus*	1721
Sand gobies *Pomatoschistus* spp.	599
Whiting *Merlangius merlangus*	104
Herring *Clupea harengus*	92
Sandeel *Ammodytes tobianus*	32
Sea lamprey *Petromyzon marinus*	27
Grey mullet *Mugil cephalus*	10
Sea snail *Liparis liparis*	8
Poor cod *Trisopterus minutus*	4
Greater pipe fish *Syngnathus acus*	4
Dover sole *Solea solea*	4
Dab *Limanda limanda*	2
Crystal goby *Crystalgobius linearis*	2
Flounder *Platichthys flesus*	2
Five-bearded rockling *Ciliata mustela*	2
Lumpsucker *Cyclopterus lumpus*	1
Solenette *Buglossidium luteum*	1
Blue whiting *Micromesistius poutassou*	1
Pearl side *Maurolicus mulleri*	1
Greater sand eel *Hyperoplus lanceolatus*	1
Three Spined stickleback *Gastrosteus aculeatus*	1
Sandeel spp. *Ammodytes*	1
Rockling spp.	1

Table 3. Number and abundance (number per m^3) of eels caught during the two V profile transects, by transect station and the mean abundance of eels caught across each transect. Stations were numbered T1 for the most northerly station and T 9 for the most southerly station.

	Number of eels			Abundance (no per m^3)	
Transect station	**Transect S-N**	**Transect N-S**	**Total**	**Transect S-N**	**Transect N-S**
TNS1	6	6	12	0.000039	0.000045
TNS2	5	0	5	0.000030	0
TNS3	4	0	4	0.000026	0
TNS4	6	3	9	0.000039	0.000029
TNS5	5	0	5	0.000037	0
TNS6	26	1	27	0.000163	0.000009
TNS7	11	0	13	0.000079	0.000016
TNS8	5	2	5	0.000040	0
TNS9	16	12	28	0.000125	0.000013
	84	**24**	**108**	**0.000064**	**0.000007**

Table 4. Number of stations fished, number of eels caught, and mean eel abundance (number per m^3), by fishing depth and by fishing site

	Number of stations fished					Number of eels caught					Mean eel abundance (number per m^3)			
Site	0 m	4 m	7 m	V profile	Total	0 m	4 m	7 m	V profile	Total	0 m	4 m	7 m	V profile
Hinkley Point B	12	4	2		18	254	64	43		361	0.00020	0.00013	0.00018	
Hinkley Point C	8	7	6		21	115	69	105		289	0.00012	0.00008	0.00014	
Lilstock	3	4	2		9	0	80	29		109	0.00000	0.00016	0.00011	
Parret	5	5	3		13	46	33	34		113	0.00007	0.00005	0.00008	
English Parallel	7	5	5		17	173	118	86		376	0.00021	0.00018	0.00014	
Penarth	4	3	2		9	88	45	22		155	0.00016	0.00012	0.00008	
Transect S-N				9	9				84	84				0.00001
Transect N-S				10	10				24	24				0.00006
Welsh Parallel	4	4	3		11	52	16	8		74	0.00009	0.00003	0.00002	
Welsh Parallel (2)	6	1			7	82	16			104	0.00009	0.00011		
Welsh Parallel (3)	5	1			6	231	16			241	0.00034	0.00011		
Total	54	34	23	19	130	1041	457	327	102	1930	0.00014	0.00011	0.00011	0.00003

Table 5. Number of stations fished, number of eels caught, and mean eel abundance (number per m^3), by time of day and by fishing site.

	Number of stations fished				**Number of eels caught**				**Mean eel abundance (number per m^3)**		
Station	Daylight	Dusk	Dark	Total	Daylight	Dusk	Dark	Total	Daylight	Dusk	Dark
Valid tows											
Hinkley Point B	10	2	6	18	142	106	113	361	0.000102	0.000489	0.000543
Hinkley Point C	3	4	14	21	25	32	232	289	0.000093	0.000471	0.000169
Lilstock	9			9	109			109	0.000000		
Parret	13			13	113			113	0.000000		
English Parallel	8	5	5	18	173	67	136	376	0.000104	0.000167	0.000501
Penarth	7	1	1	9	142	2	11	155	0.000002	0.000082	0.001159
Transect N-S	9			9	24			24	0.000000		
Transect S-N	6	2	2	10	63	10	11	84	0.000011	0.000034	0.000249
Welsh Parallel	10			10	73	1		76	0.000001		
Welsh Parallel (2)			7	7			98	98			0.000097
Welsh Parallel (3)			6	6			247	247			0.000298
	75	**14**	**41**	**130**	**864**	**218**	**848**	**1930**	**0.000035**	**0.000249**	**0.000431**

Table 6. Number of stations fished, number of eels caught, and mean eel abundance (number per m^3), by state of tide and by fishing site.

	Number of stations fished			**Number of eels caught**			**Mean eel abundance (number per m^3)**	
Station	Flood	Ebb	Total	Flood	Ebb	Total	Flood	Ebb
Valid tows								
Hinkley Point B	15	3	18	245	116	361	0.000143	0.000372
Hinkley Point C	21	0	21	289		289	0.000113	
Lilstock	8	1	9	109		109	0.000107	0.000000
Parret	9	4	13	82	31	113	0.000067	0.000058
English Parallel	17		17	376		376	0.000177	
Penarth	7	2	9	109	35	144	0.000124	0.000144
Transect N-S	9		9	24		24	0.000007	
Transect S-N	9	1	10	74	10	84	0.000055	0.000079
Welsh Parallel	9	2	11	73	12	85	0.000049	0.000048
Welsh Parallel (2)	6	1	7	95	9	104	0.000109	0.000025
Welsh Parallel (3)	5	1	6	241		2417	0.000347	0.000057
	71	**16**	**130**	**1717**	**213**	**1930**	**0.000118**	**0.000098**

A.2 April 2013 (Hink 2/13)

CENTRE FOR ENVIRONMENT, FISHERIES AND AQUACULTURE SCIENCE, LOWESTOFT LABORATORY, LOWESTOFT, SUFFOLK NR33 OHT

BEEMS CONTRACT. WP2 NEARSHORE 2013 SURVEYS

HINKLEY POINT: SITE C

REPORT: MFV Cerulean cruise 2/13

SKIPPER: J Richards

CEFAS STAFF: R Bush (4 - 12 April) SIC
G Burt (4 - 8 April)
R Beckett (8 – 12 April)

DURATION: 4 -12 April 2013

LOCATION: Hinkley Point

AIMS:

3. Determine the abundance and distribution of glass eels across the Severn estuary between River Parrett on the North Devon coast, and Lavernock Point on the South Wales coast.

4. Determine the abundance and distribution of glass eels in the vicinity of the current Hinkley Point ‘B’ intakes and the intakes of the proposed Hinkley ‘C’ new nuclear build and investigate the effect of depth, salinity, and tidal state on eel abundance.

5. Collect 200 eels and for life history development and pigmentation analysis.

6. Photograph any suspected Sea Lamprey *Petromyzon marinus.*

NARRATIVE:

Cefas staff travelled over to Cardiff on 4th April to meet the boat and crew of FV Cerulean. All survey gear was unloaded and setup, and after a quick consultation with the skipper a plan for the following day was arranged. Cefas staff their returned to their accommodation.

FV Cerulean sailed at 0515 the following morning and headed south for the first site at English Parallel. The wind was blowing from the NE force 4-5 which made for a lively sea state. Over the course of the day the wind increased to force 6, and coupled with a wind against the tide resulted in a very poor choppy sea state. As a result, only 8 stations were fished, 79 eels were caught with 31 being retained. The FV Cerulean returned to Penarth and docked around 18:30 that evening.

FV Cerulean sailed at 0630 on the morning of 6th April and steamed to the most northern transect site just off Lavernock Point. The wind had decreased from the previous day but was still coming from east. Over the course of the day 8 further transects stations were fished, with 33 eels being caught and retained. FV Cerulean returned to Penarth and docked around 1845.

Over the next two days, sites at River Parrett and the proposed intake for Hinkley 'C' were fished, 35 and 27 eels were caught at each respective site, with 20 and 22 eels being retained. At the River Parrett site, two suspected Sea Lamprey *Petromyzon marinus* were caught and photographed before being returned alive. By this point of the survey it was clear that eel and finfish numbers were markedly less than those observed during the Hink 1/13 survey. On downloading the CTD that evening it was noted that the sea temp was 1°C cooler than in February.

On Tuesday 9th April a planned staff change occurred with Gary Burt returning to Lowestoft and Rachel Beckett joining the boat for the last three days of the survey.

FV Cerulean departed Penarth at around 0900 and headed south to fish the Hinkley Point 'B' area. The weather had improved with the wind from the NW force 2-3, which made a significant improvement to the temperature and the sea state. A total of 9 stations were fished with 54 eels being caught and 23 retained for further analysis. The FV Cerulean returned to Penarth and docked on or around 1945.

For the penultimate day's fishing the transect stations were repeated from south to north. A total of 9 stations were fished with 34 eels caught and 21 retained before the FV Cerulean returned to Penarth, docking around 2030.

On the last day (11th April), FV Cerulean departed Penarth around 1130, to fish the site at Penarth, just south of Lavernock Point. The weather for the last day was near-perfect, a slight SW breeze of force 2-3 with some scattered showers. Over the course of the flood tide 9 stations were fished with 71 eels caught and 22 retained for further analysis back at the lab. On completion of the final haul the Cerulean returned to Penarth whereupon all survey gear was unloaded off the boat and the boat and crew headed back to Bideford. Cefas staff travelled back to Lowestoft the following day (12th April).

RESULTS:

8) A total of 63 valid stations were completed during the survey. A breakdown of the number of stations, by sampling location and time of day is given in Table 1. Station positions are plotted in Figure 1.

9) A total of 334 eels were caught during the survey, ranging in size from 60-85mm (Figure 2).

10) A total of 13 other finfish species were caught and measured to the nearest half cm (Table 2).

11) Eels were distributed across the entire estuary when sampling using the 'V' profile (Table 3). By number, more fish were caught in transect station T1, which is the station closest to the Welsh shore, but whether abundance was significantly higher in this site has yet to be investigated statistically.

12) Eels were distributed in the vicinity of the current Hinkley Point ‘B’ station intakes, the proposed Hinkley Point ‘C’ intakes (which are further offshore) and off the River Parrett further east.

13) As in Hink 1/13 eels were most abundant in tows conducted at the surface (Table 4). Only daytime tows were fished for Hink 2/13 due to the tide times and the length of the survey. (The 7 days of the Hink 2/13 survey correspond to the first 7 days of Hink 1/13 with respect to the lunar cycle).

14) It should be noted that eel catches were down by 66%, when compared to the average daily catches observed during the Hink 1/13 survey. Other finfish catches were also reduced by 85% when compared to average daily catch rates of the first survey.

Our thanks go to the skipper and crew of the FV Cerulean for their hard work in making the survey successful

R Bush 22 April 2013

Table 1. Number of stations sampled during the Hink 2/13 survey

Station	Daylight	Dusk	Darkness	Total
Valid tows				
Hinkley Point B	9	0	0	9
Hinkley Point C	9	0	0	9
Parrett	10	0	0	10
English Parallel	8	0	0	8
Penarth	9	0	0	9
Transect N-S	9	0	0	9
Transect S-N	9	0	0	9
Total	**63**	**0**	**0**	**63**

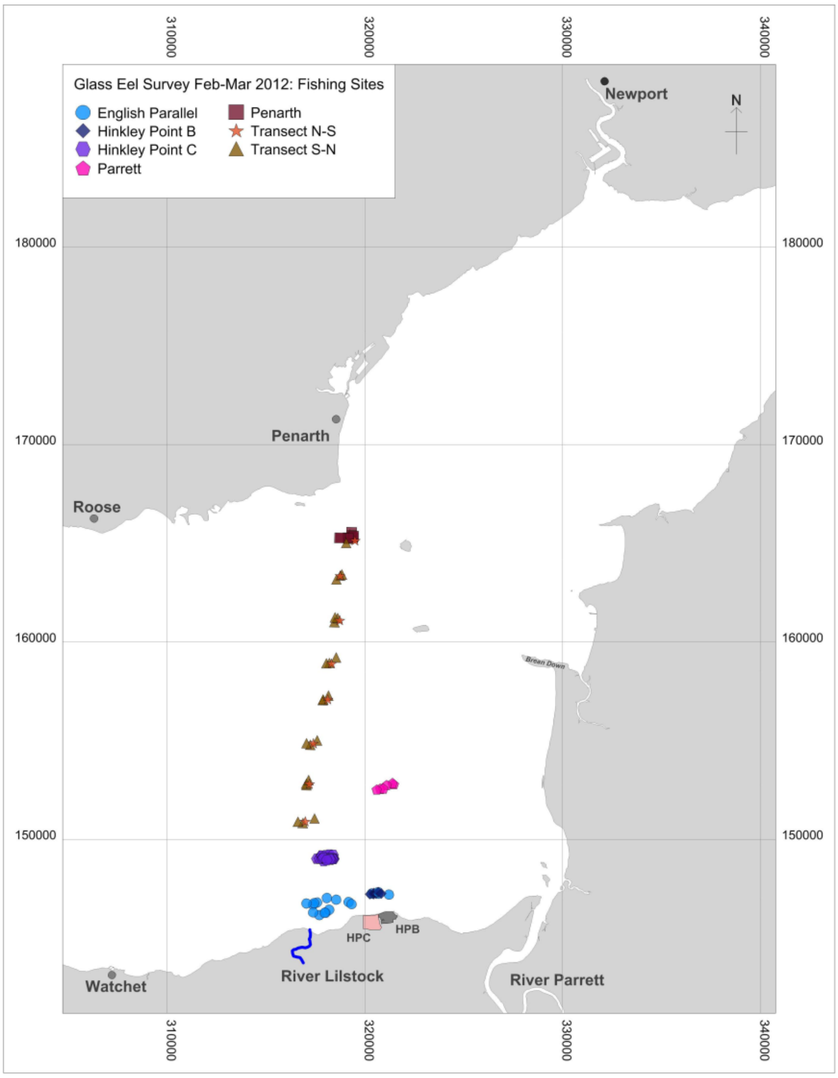


Figure 1. Position of all stations fished during the Hink 2/13 survey, by survey site

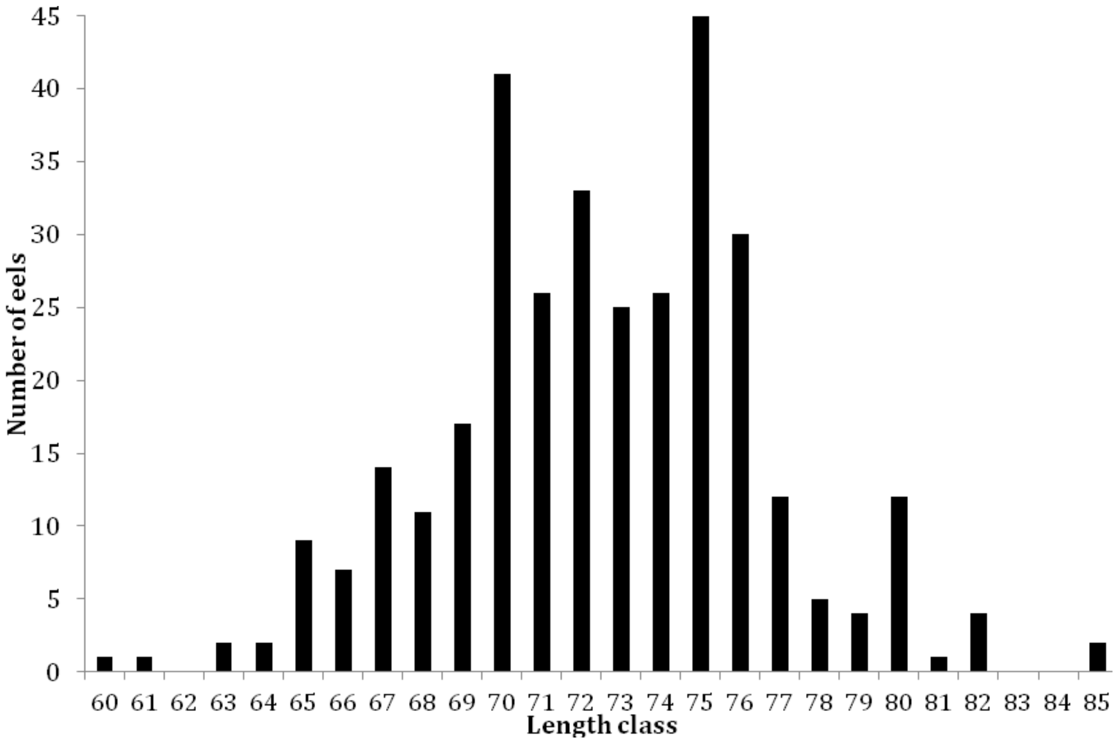


Figure 2. Length distribution of all eels caught during Hink 2/13

Table 2. Total numbers of fish captured during Hink 2/13

Species	Number
European eel *Anguilla anguilla*	334
Sand gobies *Pomatoschistus* spp.	97
Solenette *Buglossidium luteum*	40
Sprat *Sprattus sprattus*	21
Whiting *Merlangius merlangus*	15
Herring *Clupea harengus*	8
Sea lamprey *Petromyzon marinus*	5
Grey mullet *Mugil cephalus*	4
Flounder *Platichthys flesus*	3
Sea snail *Liparis liparis*	2
Greater Pipe Fish *Syngnathus acus*	1
Dover sole *Solea solea*	1
Jeffrey's goby *Beunia jeffreysii*	1

Table 3. Number and abundance (number per m^3) of eels caught during the two V profile transects, by transect station, and mean abundance of eels across each transect. Stations were numbered T1 for the most northerly station and T9 for the most southerly station

Transect station	Number of eels: Transect S-N	Transect N-S	Total	Abundance (no per m3): Transect S-N	Transect N-S
TNS1	12	0	12	0.000009	0.000000
TNS2	2	5	7	0.000066	0.000043
TNS3	1	4	5	0.000052	0.000032
TNS4	1	3	4	0.000010	0.000024
TNS5	5	3	8	0.000044	0.000024
TNS6	1	7	8	0.000010	0.000055
TNS7	5	2	7	0.000007	0.000015
TNS8	6	1	7	0.000014	0.000007
TNS9	1	8	9	0.000092	0.000059
	34	**33**	**67**	**0.000034**	**0.000029**

Table 4. Number of stations fished, number of eels caught, and mean eel abundance (number per m^3), by fishing depth and by fishing site

	Number of stations fished					Number of eels caught					Mean eel abundance (number per m^3)			
Site	0 m	4 m	7 m	V profile	Total	0 m	4 m	7 m	V profile	Total	0 m	4 m	7 m	V profile
Hinkley Point B	3	3	3		9	43	7	5		55	0.000135	0.000019	0.000014	
Hinkley Point C	3	3	3		9	9	13	5		27	0.000026	0.000029	0.000012	
Parret	3	3	4		10	11	9	15		35	0.000031	0.000024	0.000030	
English Parallel	3	3	2		8	17	42	20		79	0.000044	0.000100	0.000086	
Penarth	3	3	3		9	37	16	18		71	0.000116	0.000040	0.000044	
Transect N-S				9	9				33	33				0.000029
Transect S-N				9	9				34	34				0.000034
	15	**15**	**15**	**18**	**63**	**117**	**87**	**63**	**67**	**334**	**0.000071**	**0.000042**	**0.000037**	**0.000031**

Table 5. Number of stations fished, number of eels caught, and mean eel abundance (number per m^3), by time of day and by fishing site

	Number of stations fished				**Number of eels caught**				**Mean eel abundance (number per m^3)**		
Station	Daylight	Dusk	Darkness	Total	Daylight	Dusk	Darkness	Total	Daylight	Dusk	Darkness
Valid tows											
Hinkley Point B	9	0	0	9	55	0	0	55	0.00006	0	0
Hinkley Point C	9	0	0	9	27	0	0	27	0.00002	0	0
Parret	10	0	0	10	35	0	0	35	0.00003	0	0
English Parallel	8	0	0	8	79	0	0	79	0.00008	0	0
Penarth	9	0	0	9	71	0	0	71	0.00007	0	0
Transect N-S	9	0	0	9	33	0	0	33	0.00003	0	0
Transect S-N	9	0	0	9	34	0	0	34	0.00003	0	0
Total	**63**	**0**	**0**	**63**	**334**	**0**	**0**	**334**	**0.00004**	**0**	**0**

Appendix B Survey station details

B.1 February 2013 (Hink 1/13)

Station data (shot and haul date, time, position and duration), site data (fishing site, depth, tidal state, daylight, volume of water filtered), physical data (average temperature and salinity), absolute numbers of eels caught and eel abundance (numbers per m^3 water filtered), by station for the February 2013 (Hink 1/13) survey. Neap tides were on 19th February

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
1	19-Feb-13	17:50	19-Feb-13	18:05	15	51.233	-3.177	51.235	-3.165	11	11	Hinkley Point C	4 m	Flood	Dusk	V	6.02	23.18	10	2240.5	0.0045
2	19-Feb-13	18:25	19-Feb-13	18:41	16	51.233	-3.178	51.236	-3.163	11	10	Hinkley Point C	7 m	Flood	Dusk	V	6	23.61	10	1999.7	0.0050
3	19-Feb-13	18:59	19-Feb-13	19:14	15	51.234	-3.175	51.236	-3.161	11	10	Hinkley Point C	0 m	Flood	Dark	V	6.04	21.58	7	1898.5	0.0037
4	19-Feb-13	19:50	19-Feb-13	20:05	15	51.235	-3.166	51.232	-3.179	10	12	Hinkley Point C	0 m	Flood	Dark	V	5.99	21.72	11	1997.7	0.0055
5	19-Feb-13	20:19	19-Feb-13	20:34	15	51.235	-3.167	51.232	-3.180	11	12	Hinkley Point C	4 m	Flood	Dark	V	5.97	23.25	11	2279.0	0.0048
6	19-Feb-13	20:55	19-Feb-13	21:11	16	51.235	-3.166	51.233	-3.180	11	13	Hinkley Point C	7 m	Flood	Dark	V	6.43	26.96	14	2508.4	0.0056
7	19-Feb-13	21:25	19-Feb-13	21:40	15	51.235	-3.166	51.233	-3.179	12	13	Hinkley Point C	0 m	Flood	Dark	V	5.77	22.02	23	2785.5	0.0083
8	19-Feb-13	21:58	19-Feb-13	22:13	15	51.235	-3.166	51.232	-3.179	12	13	Hinkley Point C	4 m	Flood	Dark	V	6.23	25.46	16	2480.9	0.0064
9	19-Feb-13	22:38	19-Feb-13	22:53	15	51.235	-3.168	51.232	-3.182	13	15	Hinkley Point C	7 m	Flood	Dark	V	6.48	27.28	13	2556.1	0.0051
10	19-Feb-13	23:10	19-Feb-13	23:25	15	51.235	-3.167	51.232	-3.179	13	15	Hinkley Point C	0 m	Flood	Dark	V	5.72	22.37	18	2294.6	0.0078
11	20-Feb-13	09:15	20-Feb-13	09:30	15	51.381	-3.160	51.381	-3.173	18	16	Transect N-S	V profile	Flood	Day	V	5.96	22.96	6	2699.8	0.0022
12	20-Feb-13	09:50	20-Feb-13	10:05	15	51.363	-3.166	51.361	-3.178	23	26	Transect N-S	V profile	Flood	Day	V	6.03	23.63	0	2133.0	0.0000

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
13	20-Feb-13	10:24	20-Feb-13	10:39	15	51.344	-3.167	51.343	-3.180	26	22	Transect N-S	V profile	Flood	Day	V	5.94	23.31	0	1734.2	0.0000
14	20-Feb-13	10:56	20-Feb-13	11:11	15	51.324	-3.173	51.324	-3.185	17	19	Transect N-S	V profile	Flood	Day	V	5.95	23.86	3	2087.6	0.0014
15	20-Feb-13	11:27	20-Feb-13	11:42	15	51.306	-3.176	51.305	-3.187	15	15	Transect N-S	V profile	Flood	Day	V	5.82	23.38	0	2136.4	0.0000
16	20-Feb-13	11:58	20-Feb-13	12:13	15	51.287	-3.181	51.287	-3.192	18	18	Transect N-S	V profile	Flood	Day	V	5.79	23.38	1	2164.0	0.0005
17	20-Feb-13	12:31	20-Feb-13	12:46	15	51.269	-3.184	51.269	-3.196	16	16	Transect N-S	V profile	Flood	Day	V	6.77	29.18	2	2577.1	0.0008
18	20-Feb-13	13:05	20-Feb-13	13:20	15	51.251	-3.186	51.251	-3.198	16	17	Transect N-S	V profile	Flood	Day	V	6.86	29.73	0	3489.8	0.0000
19	20-Feb-13	13:43	20-Feb-13	13:58	15	51.235	-3.166	51.233	-3.180	14	15	Transect N-S	V profile	Flood	Day	V	6.75	29.09	12	1836.4	0.0065
20	21-Feb-13	10:03	21-Feb-13	10:18	15	51.218	-3.244	51.219	-3.231	13	11	Lilstock	0 m	Ebb	Day	V	6.44	27.74	0	2297.1	0.0000
21	21-Feb-13	10:32	21-Feb-13	10:47	15	51.218	-3.243	51.220	-3.229	14	11	Lilstock	4 m	Flood	Day	V	6.58	29.06	4	1537.1	0.0026
22	21-Feb-13	11:02	21-Feb-13	11:17	15	51.219	-3.230	51.218	-3.243	12	14	Lilstock	0 m	Flood	Day	V	6.67	29.56	0	2114.3	0.0000
23	21-Feb-13	11:29	21-Feb-13	11:45	16	51.219	-3.230	51.218	-3.243	14	15	Lilstock	4 m	Flood	Day	V	6.77	29.91`	45	2624.7	0.0171
24	21-Feb-13	12:14	21-Feb-13	12:29	15	51.219	-3.229	51.218	-3.241	13	14	Lilstock	7 m	Flood	Day	V	6.84	30.37	14	2594.8	0.0054
25	21-Feb-13	12:57	21-Feb-13	13:12	15	51.219	-3.231	51.218	-3.243	14	16	Lilstock	0 m	Flood	Day	V	6.72	30.14	0	2252.5	0.0000
26	21-Feb-13	13:23	21-Feb-13	13:39	16	51.219	-3.230	51.218	-3.244	16	17	Lilstock	4 m	Flood	Day	V	6.82	30.68	21	2783.1	0.0075
27	21-Feb-13	13:58	21-Feb-13	14:13	15	51.219	-3.231	51.219	-3.245	16	17	Lilstock	7 m	Flood	Day	V	6.89	30.14	15	2566.4	0.0058
28	21-Feb-13	14:35	21-Feb-13	14:51	16	51.219	-3.230	51.219	-3.244	17	17	Lilstock	4 m	Flood	Day	V	6.91	31.05	10	2787.3	0.0036

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
29	22-Feb-13	10:23	22-Feb-13	10:38	15	51.219	-3.145	51.220	-3.132	6	6	Hinkley Point B	-	-	-	I	5.66	26.7	-	-	-
30	22-Feb-13	11:37	22-Feb-13	11:52	15	51.219	-3.129	51.217	-3.145	6	6	Hinkley Point B	0 m	Flood	Day	V	5.48	25.94	2	2175.8	0.0009
31	22-Feb-13	12:03	22-Feb-13	12:19	16	51.220	-3.133	51.219	-3.145	7	7	Hinkley Point B	0 m	Flood	Day	V	5.57	26.17	7	2036.0	0.0034
32	22-Feb-13	12:30	22-Feb-13	12:45	15	51.220	-3.133	51.219	-3.145	8	8	Hinkley Point B	0 m	Flood	Day	V	5.56	26.27	5	2217.1	0.0023
33	22-Feb-13	12:59	22-Feb-13	13:15	16	51.219	-3.132	51.218	-3.145	8	9	Hinkley Point B	0 m	Flood	Day	V	5.71	26.75	6	2697.2	0.0022
34	22-Feb-13	13:28	22-Feb-13	13:43	15	51.220	-3.129	51.219	-3.141	9	10	Hinkley Point B	0 m	Flood	Day	V	5.97	26.58	5	2724.6	0.0018
35	22-Feb-13	13:58	22-Feb-13	14:14	16	51.219	-3.130	51.219	-3.141	10	11	Hinkley Point B	4 m	Flood	Day	V	6.06	27.86	24	2414.5	0.0099
36	22-Feb-13	14:48	22-Feb-13	15:04	16	51.218	-3.131	51.217	-3.145	11	12	Hinkley Point B	4 m	Flood	Day	V	6.12	28.37	20	2654.3	0.0075
37	22-Feb-13	15:33	22-Feb-13	15:49	16	51.219	-3.133	51.219	-3.148	12	13	Hinkley Point B	7 m	Flood	Day	V	6.24	28.77	20	2497.3	0.0080
38	23-Feb-13	10:01	23-Feb-13	10:16	15	51.268	-3.137	51.268	-3.129	10	9	Parrett	0 m	Ebb	Day	V	5.73	24.96	9	2638.1	0.0034
39	23-Feb-13	10:34	23-Feb-13	10:49	15	51.267	-3.134	51.267	-3.125	9	9	Parrett	4 m	Ebb	Day	V	5.86	25.79	6	2382.7	0.0025
40	23-Feb-13	11:05	23-Feb-13	11:20	15	51.268	-3.128	51.268	-3.120	9	9	Parrett	0 m	Ebb	Day	V	5.72	25.22	16	2914.1	0.0055
41	23-Feb-13	11:33	23-Feb-13	11:48	15	51.268	-3.128	51.269	-3.113	9	9	Parrett	4 m	Ebb	Day	V	5.75	25.29	0	2265.4	0.0000
42	23-Feb-13	12:33	23-Feb-13	12:48	15	51.268	-3.118	51.268	-3.133	10	10	Parrett	4 m	Flood	Day	V	5.74	25.18	2	2338.3	0.0009
43	23-Feb-13	13:02	23-Feb-13	13:17	15	51.268	-3.119	51.268	-3.132	10	10	Parrett	0 m	Flood	Day	V	5.74	25.24	7	2682.6	0.0026
44	23-Feb-13	13:29	23-Feb-13	13:45	16	51.268	-3.119	51.267	-3.129	11	11	Parrett	4 m	Flood	Day	V	5.77	25.32	7	2517.6	0.0028

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
45	23-Feb-13	14:00	23-Feb-13	14:16	16	51.268	-3.119	51.268	-3.128	12	12	Parrett	7 m	Flood	Day	V	5.85	25.76	15	2928.6	0.0051
46	23-Feb-13	14:31	23-Feb-13	14:46	15	51.269	-3.115	51.268	-3.124	13	13	Parrett	0 m	Flood	Day	V	5.87	25.89	18	2952.2	0.0061
47	23-Feb-13	15:04	23-Feb-13	15:20	16	51.269	-3.114	51.268	-3.125	14	14	Parrett	4 m	Flood	Day	V	5.9	26.33	3	2841.1	0.0011
48	23-Feb-13	15:29	23-Feb-13	15:44	15	51.268	-3.116	51.267	-3.124	15	15	Parrett	7 m	Flood	Day	V	5.98	26.72	9	2686.9	0.0033
49	23-Feb-13	16:02	23-Feb-13	16:17	15	51.268	-3.116	51.267	-3.126	16	16	Parrett	0 m	Flood	Day	V	6.01	27.3	11	2632.3	0.0042
50	23-Feb-13	16:27	23-Feb-13	16:43	16	51.268	-3.118	51.267	-3.130	16	16	Parrett	7 m	Flood	Day	V	6.05	27.73	10	2843.1	0.0035
51	24-Feb-13	12:35	24-Feb-13	12:50	15	51.215	-3.184	51.214	-3.198	5	5	English parallel	0 m	Flood	Day	V	4.91	25.1	13	2266.3	0.0057
52	24-Feb-13	13:11	24-Feb-13	13:26	15	51.217	-3.159	51.215	-3.171	5	6	English parallel	0 m	Flood	Day	V	4.84	24.98	15	2392.4	0.0063
53	24-Feb-13	13:45	24-Feb-13	14:00	15	51.219	-3.132	51.218	-3.142	6	7	English parallel	0 m	Flood	Day	V	4.78	24.87	29	2785.7	0.0104
54	24-Feb-13	14:32	24-Feb-13	14:47	15	51.215	-3.184	51.213	-3.198	9	9	English parallel	4 m	Flood	Day	V	5.29	26.49	35	3231.9	0.0108
55	24-Feb-13	15:14	24-Feb-13	15:29	15	51.217	-3.158	51.216	-3.168	9	10	English parallel	4 m	Flood	Day	V	5.26	26.41	17	2534.9	0.0067
56	24-Feb-13	15:50	24-Feb-13	16:05	15	51.219	-3.133	51.218	-3.143	11	12	English parallel	4 m	Flood	Day	V	5.24	26.4	15	2545.3	0.0059
57	24-Feb-13	16:35	24-Feb-13	16:51	16	51.215	-3.183	51.214	-3.193	12	13	English parallel	7 m	Flood	Dusk	V	5.51	27.62	11	2575.4	0.0043
58	24-Feb-13	17:09	24-Feb-13	17:25	16	51.217	-3.160	51.214	-3.173	13	13	English parallel	7 m	Flood	Dusk	V	5.51	27.72	8	2578.1	0.0031
59	24-Feb-13	17:46	24-Feb-13	18:01	15	51.219	-3.134	51.217	-3.149	14	14	English parallel	7 m	Flood	Dusk	V	5.48	27.57	11	2555.4	0.0043
60	25-Feb-13	11:52	25-Feb-13	12:07	15	51.388	-3.235	51.389	-3.221	12	8	Welsh parallel	4 m	Ebb	Day	V	-	-	3	2357.9	0.0013

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
61	25-Feb-13	12:18	25-Feb-13	12:33	15	51.388	-3.235	51.390	-3.223	12	8	Welsh parallel	0 m	Ebb	Day	V	-	-	9	2568.7	0.0035
62	25-Feb-13	13:11	25-Feb-13	13:26	15	51.389	-3.227	51.388	-3.241	9	13	Welsh parallel	0 m	Flood	Day	V	-	-	9	2464.8	0.0037
63	25-Feb-13	13:40	25-Feb-13	13:55	15	51.389	-3.208	51.388	-3.219	11	10	Welsh parallel	0 m	Flood	Day	V	-	-	7	2664.2	0.0026
64	25-Feb-13	14:08	25-Feb-13	14:23	15	51.390	-3.188	51.389	-3.194	12	14	Welsh parallel	0 m	Flood	Day	V	-	-	27	3250.7	0.0083
65	25-Feb-13	14:40	25-Feb-13	14:55	15	51.387	-3.229	51.388	-3.242	11	15	Welsh parallel	4 m	Flood	Day	V	-	-	5	2543.8	0.0020
66	25-Feb-13	15:12	25-Feb-13	15:27	15	51.389	-3.209	51.388	-3.217	14	12	Welsh parallel	4 m	Flood	Day	V	-	-	3	2782.9	0.0011
67	25-Feb-13	15:42	25-Feb-13	15:57	15	51.390	-3.188	51.389	-3.193	15	17	Welsh parallel	4 m	Flood	Day	V	-	-	5	4053.8	0.0012
68	25-Feb-13	16:16	25-Feb-13	16:32	16	51.388	-3.233	51.388	-3.244	17	20	Welsh parallel	7 m	Flood	Day	V	-	-	2	2087.7	0.0010
69	25-Feb-13	16:49	25-Feb-13	17:05	16	51.389	-3.209	51.388	-3.220	17	17	Welsh parallel	7 m	Flood	Day	V	-	-	3	3285.8	0.0009
70	25-Feb-13	17:19	25-Feb-13	17:35	16	51.390	-3.188	51.389	-3.196	20	22	Welsh parallel	7 m	Flood	Dusk	V	-	-	1	3053.6	0.0003
71	25-Feb-13	17:48	25-Feb-13	18:03	15	51.390	-3.189	51.390	-3.195	22	24	Penarth	0 m	Flood	Dark	V	-	-	11	2715.5	0.0041
72	26-Feb-13	12:56	26-Feb-13	13:12	16	51.381	-3.170	51.381	-3.161	15	16	Penarth	4 m	Ebb	Day	V	-	-	15	2694.4	0.0056
73	26-Feb-13	13:30	26-Feb-13	13:45	15	51.381	-3.168	51.381	-3.157	15	14	Penarth	4 m	Ebb	Day	V	-	-	20	2308.0	0.0087
74	26-Feb-13	14:01	26-Feb-13	14:16	15	51.381	-3.157	51.380	-3.172	12	15	Penarth	0 m	Flood	Day	V	-	-	26	2248.0	0.0116
75	26-Feb-13	14:32	26-Feb-13	14:47	15	51.382	-3.156	51.381	-3.166	12	16	Penarth	0 m	Flood	Day	V	-	-	28	3055.5	0.0092
76	26-Feb-13	15:08	26-Feb-13	15:23	15	51.381	-3.158	51.381	-3.163	14	16	Penarth	4 m	Flood	Day	V	-	-	10	2834.3	0.0035

St n.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
77	26-Feb-13	15:36	26-Feb-13	15:52	16	51.382	-3.160	51.383	-3.162	16	16	Penarth	7 m	Flood	Day	V	-	-	20	2935.9	0.0068
78	26-Feb-13	16:14	26-Feb-13	16:29	15	51.382	-3.157	51.382	-3.162	17	19	Penarth	0 m	Flood	Day	V	-	-	23	3182.8	0.0072
79	26-Feb-13	16:50	26-Feb-13	17:06	16	51.382	-3.156	51.382	-3.160	18	20	Penarth	7 m	Flood	Dusk	V	-	-	2	3118.8	0.0006
80	27-Feb-13	13:17	27-Feb-13	13:32	15	51.232	-3.180	51.234	-3.169	7	8	Transect S-N	V profile	Ebb	Day	V	5.33	26.03	10	2577.7	0.0039
81	27-Feb-13	14:50	27-Feb-13	15:05	15	51.235	-3.172	51.233	-3.184	8	9	Transect S-N	V profile	Flood	Day	V	5.31	25.78	6	2615.0	0.0023
82	27-Feb-13	15:21	27-Feb-13	15:36	15	51.251	-3.183	51.250	-3.195	10	11	Transect S-N	V profile	Flood	Day	V	5.21	24.56	5	2555.4	0.0020
83	27-Feb-13	15:49	27-Feb-13	16:04	15	51.268	-3.181	51.268	-3.188	12	12	Transect S-N	V profile	Flood	Day	V	5.25	24.89	11	2815.3	0.0039
84	27-Feb-13	16:22	27-Feb-13	16:37	15	51.287	-3.179	51.288	-3.182	15	16	Transect S-N	V profile	Flood	Day	V	5.31	25.39	26	3236.2	0.0080
85	27-Feb-13	16:52	27-Feb-13	17:08	16	51.306	-3.178	51.307	-3.186	13	13	Transect S-N	V profile	Flood	Day	V	5.41	26.02	5	2764.4	0.0018
86	27-Feb-13	17:22	27-Feb-13	17:37	15	51.324	-3.174	51.325	-3.182	19	20	Transect S-N	V profile	Flood	Dusk	V	5.65	27.27	6	3108.1	0.0019
87	27-Feb-13	17:52	27-Feb-13	18:07	15	51.343	-3.169	51.343	-3.175	26	22	Transect S-N	V profile	Flood	Dusk	V	5.75	27.61	4	3112.0	0.0013
88	27-Feb-13	18:21	27-Feb-13	18:36	15	51.362	-3.164	51.363	-3.170	30	29	Transect S-N	V profile	Flood	Dark	V	5.82	27.82	5	3366.3	0.0015
89	27-Feb-13	18:48	27-Feb-13	19:04	16	51.382	-3.158	51.382	-3.163	22	24	Transect S-N	V profile	Flood	Dark	V	5.91	28.27	6	3146.1	0.0019
90	28-Feb-13	18:18	28-Feb-13	18:34	16	51.467	-3.042	51.466	-3.049	11	10	Welsh parallel (2)	0 m	Flood	Dark	V	4.91	22.79	26	3097.6	0.0084
91	28-Feb-13	18:52	28-Feb-13	19:07	15	51.468	-3.042	51.466	-3.050	12	13	Welsh parallel (2)	4 m	Flood	Dark	V	4.99	23.77	16	2923.6	0.0055
92	28-Feb-13	19:23	28-Feb-13	19:39	16	51.470	-3.069	51.467	-3.076	12	13	Welsh parallel (2)	0 m	Flood	Dark	V	5.18	24.93	32	2899.7	0.0110

Stn	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
93	28-Feb-13	19:54	28-Feb-13	20:09	15	51.473	-3.075	51.468	-3.083	13	13	Welsh parallel (2)	0 m	Flood	Dark	V	5.21	25.28	7	2835.5	0.0025
94	28-Feb-13	20:19	28-Feb-13	20:35	16	51.477	-3.078	51.469	-3.089	13	14	Welsh parallel (2)	0 m	Flood	Dark	V	5.21	24.73	11	2927.1	0.0038
95	28-Feb-13	20:45	28-Feb-13	21:00	15	51.461	-3.117	51.451	-3.132	14	14	Welsh parallel (2)	0 m	Flood	Dark	V	5.32	25.81	3	2744.7	0.0011
96	28-Feb-13	21:12	28-Feb-13	21:27	15	51.448	-3.137	51.452	-3.128	12	13	Welsh parallel (2)	0 m	Ebb	Dark	V	5.35	25.05	3	2428.5	0.0012
97	01-Mar-13	18:52	01-Mar-13	19:07	15	51.487	-3.001	51.483	-3.007	10	9	Welsh parallel (3)	0 m	Flood	Dark	V	4.7	20.68	55	2914.5	0.0189
98	01-Mar-13	19:33	01-Mar-13	19:49	16	51.487	-3.002	51.482	-3.008	11	12	Welsh parallel (3)	4 m	Flood	Dark	V	5.01	23.56	16	3008.7	0.0053
99	01-Mar-13	20:05	01-Mar-13	20:20	15	51.492	-3.000	51.488	-3.005	12	13	Welsh parallel (3)	0 m	Flood	Dark	V	4.98	23.32	34	2893.1	0.0118
100	01-Mar-13	20:34	01-Mar-13	20:49	15	51.495	-3.007	51.489	-3.014	12	13	Welsh parallel (3)	0 m	Flood	Dark	V	5.02	22.7	11	2853.6	0.0039
101	01-Mar-13	20:58	01-Mar-13	21:14	16	51.494	-3.022	51.487	-3.036	13	13	Welsh parallel (3)	0 m	Flood	Dark	V	5.16	24.03	125	2733.3	0.0457
102	02-Mar-13	16:03	02-Mar-13	16:18	15	51.234	-3.166	51.231	-3.183	7	9	Hinkley Point C	0 m	Flood	Day	V	5.26	25.46	6	2402.1	0.0025
103	02-Mar-13	16:31	02-Mar-13	16:47	16	51.234	-3.166	51.232	-3.178	7	9	Hinkley Point C	4 m	Flood	Day	V	5.21	25.68	3	2519.7	0.0012
104	02-Mar-13	16:56	02-Mar-13	17:11	15	51.235	-3.167	51.234	-3.177	8	9	Hinkley Point C	0 m	Flood	Day	V	5.25	25.65	16	2594.4	0.0062
105	02-Mar-13	17:23	02-Mar-13	17:39	16	51.236	-3.164	51.232	-3.175	9	10	Hinkley Point C	4 m	Flood	Dusk	V	5.21	25.62	6	3093.4	0.0019
106	02-Mar-13	17:47	02-Mar-13	18:02	15	51.235	-3.167	51.233	-3.174	10	11	Hinkley Point C	0 m	Flood	Dusk	V	5.2	25.28	6	2530.7	0.0024
107	02-Mar-13	18:12	02-Mar-13	18:27	15	51.235	-3.163	51.234	-3.169	10	12	Hinkley Point C	4 m	Flood	Dark	V	5.21	25.61	11	2580.5	0.0043

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
108	02-Mar-13	18:38	02-Mar-13	18:54	16	51.234	-3.166	51.233	-3.175	12	13	Hinkley Point C	7 m	Flood	Dark	V	5.21	25.84	23	2694.1	0.0085
109	02-Mar-13	19:12	02-Mar-13	19:28	16	51.234	-3.165	51.233	-3.170	13	14	Hinkley Point C	7 m	Flood	Dark	V	5.15	25.8	26	2762.8	0.0094
110	02-Mar-13	19:42	02-Mar-13	19:58	16	51.235	-3.163	51.234	-3.167	14	15	Hinkley Point C	0 m	Flood	Dark	V	5.16	25.55	28	2369.8	0.0118
111	02-Mar-13	20:12	02-Mar-13	20:27	15	51.234	-3.166	51.233	-3.175	16	16	Hinkley Point C	4 m	Flood	Dark	V	5.25	26.62	12	2732.3	0.0044
112	02-Mar-13	20:39	02-Mar-13	20:54	15	51.235	-3.169	51.232	-3.176	16	17	Hinkley Point C	7 m	Flood	Dark	V	5.31	26.95	19	2567.9	0.0074
113	02-Mar-13	22:21	02-Mar-13	22:36	15	51.427	-3.158	51.432	-3.160	14	13	Welsh parallel (2)	0 m	Ebb	Dark	V	5.31	24.01	6	2141.4	0.0028
114	03-Mar-13	16:45	03-Mar-13	17:00	15	51.216	-3.183	51.212	-3.201	5	6	English parallel	0 m	Flood	Day	V	4.86	23.37	18	2085.9	0.0086
115	03-Mar-13	17:18	03-Mar-13	17:33	15	51.217	-3.160	51.215	-3.174	5	6	English parallel	0 m	Flood	Day	V	4.85	24.38	31	2600.7	0.0119
116	03-Mar-13	17:50	03-Mar-13	18:05	15	51.220	-3.133	51.218	-3.144	6	7	English parallel	0 m	Flood	Dusk	V	4.87	24.17	37	2419.7	0.0153
117	03-Mar-13	18:54	03-Mar-13	19:09	15	51.216	-3.184	51.214	-3.194	9	10	English parallel	0 m	Flood	Dark	V	4.95	23.95	30	2320.5	0.0129
118	03-Mar-13	19:27	03-Mar-13	19:42	15	51.215	-3.161	51.215	-3.169	9	10	English parallel	4 m	Flood	Dark	V	4.98	25.57	29	2440.4	0.0119
119	03-Mar-13	19:59	03-Mar-13	20:14	15	51.219	-3.134	51.219	-3.144	11	12	English parallel	4 m	Flood	Dark	V	4.98	25.51	21	2756.6	0.0076
120	03-Mar-13	20:33	03-Mar-13	20:48	15	51.216	-3.182	51.215	-3.190	12	13	English parallel	7 m	Flood	Dark	V	5.17	26.03	22	2528.3	0.0087
121	03-Mar-13	21:04	03-Mar-13	21:19	15	51.217	-3.161	51.214	-3.170	13	13	English parallel	7 m	Flood	Dark	V	5.19	26.18	34	2515.8	0.0135
122	04-Mar-13	15:55	04-Mar-13	16:10	15	51.219	-3.142	51.220	-3.131	6	6	Hinkley Point B	0 m	Ebb	Day	V	5.02	24.9	33	2058.4	0.0160
123	04-Mar-13	16:30	04-Mar-13	16:45	15	51.219	-3.141	51.220	-3.125	5	5	Hinkley Point B	0 m	Ebb	Day	V	4.97	24.86	20	2012.2	0.0099

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
124	04-Mar-13	17:21	04-Mar-13	17:36	15	51.220	-3.132	51.218	-3.146	6	6	Hinkley Point B	0 m	Ebb	Dusk	V	5.59	24.38	63	2162.0	0.0291
125	04-Mar-13	18:03	04-Mar-13	18:18	15	51.219	-3.133	51.219	-3.144	7	7	Hinkley Point B	0 m	Flood	Dusk	V	5.44	25.03	43	2019.1	0.0213
126	04-Mar-13	18:34	04-Mar-13	18:49	15	51.220	-3.132	51.219	-3.142	8	8	Hinkley Point B	0 m	Flood	Dark	V	5.16	25.11	35	2161.4	0.0162
127	04-Mar-13	19:07	04-Mar-13	19:22	15	51.219	-3.132	51.219	-3.142	8	9	Hinkley Point B	4 m	Flood	Dark	V	5.01	25.44	4	2474.0	0.0016
128	04-Mar-13	19:33	04-Mar-13	19:49	16	51.220	-3.134	51.218	-3.141	9	9	Hinkley Point B	0 m	Flood	Dark	V	4.95	23,64	24	2350.3	0.0102
129	04-Mar-13	20:01	04-Mar-13	20:16	15	51.220	-3.133	51.220	-3.143	10	10	Hinkley Point B	4 m	Flood	Dark	V	5.01	25.5	16	2667.2	0.0060
130	04-Mar-13	20:29	04-Mar-13	20:44	15	51.219	-3.130	51.219	-3.136	10	11	Hinkley Point B	0 m	Flood	Dark	V	4.99	23.82	11	2281.5	0.0048
131	04-Mar-13	20:56	04-Mar-13	21:11	15	51.219	-3.132	51.219	-3.143	11	12	Hinkley Point B	7 m	Flood	Dark	V	5.1	25.74	23	2442.6	0.0094

B.2 April 2013 (Hink 2/13)

Station data (shot and haul date, time, position and duration), site data (fishing site, depth, tidal state, daylight, volume of water filtered), physical data (average temperature and salinity), absolute numbers of eels caught and eel abundance (numbers per m^3 water filtered), by station for the April 2013 (Hink 2/13) survey. Neap tides were on 5th April

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
1	05-Apr-13	08:28	05-Apr-13	08:44	15	51.215	-3.182	51.214	-3.200	7	6	English parallel	0 m	flood	Day	V	-	-	8	1655	0.0048
2	05-Apr-13	09:06	05-Apr-13	09:21	15	51.217	-3.157	51.216	-3.173	6	6	English parallel	0 m	flood	Day	V	-	-	8	6711	0.0012
3	05-Apr-13	09:45	05-Apr-13	10:00	15	51.219	-3.130	51.218	-3.147	7	7	English parallel	0 m	flood	Day	V	-	-	1	2129	0.0005
4	05-Apr-13	10:38	05-Apr-13	10:54	15	51.215	-3.181	51.214	-3.195	8	9	English parallel	4 m	flood	Day	V	-	-	8	2835	0.0028
5	05-Apr-13	11:16	05-Apr-13	11:31	15	51.218	-3.159	51.216	-3.172	9	9	English parallel	4 m	flood	Day	V	-	-	23	2829	0.0081
6	05-Apr-13	11:55	05-Apr-13	12:10	15	51.218	-3.130	51.217	-3.143	10	11	English parallel	4 m	flood	Day	V	-	-	11	2846	0.0039
7	05-Apr-13	12:30	05-Apr-13	12:45	15	51.215	-3.185	51.214	-3.197	11	12	English parallel	7 m	flood	Day	V	-	-	8	2453	0.0033
8	05-Apr-13	13:08	05-Apr-13	13:24	15	51.217	-3.158	51.216	-3.172	12	12	English parallel	7 m	flood	Day	V	-	-	12	2296	0.0052
9	06-Apr-13	10:07	06-Apr-13	10:22	15	51.382	-3.153	51.382	-3.166	14	16	Transect N-S	V profile	flood	Day	V	-	-	0	1947	0.0000
10	06-Apr-13	10:34	06-Apr-13	10:49	15	51.363	-3.163	51.362	-3.172	23	16	Transect N-S	V profile	flood	Day	V	-	-	5	2367	0.0021
11	06-Apr-13	11:00	06-Apr-13	11:15	15	51.345	-3.166	51.343	-3.174	17	20	Transect N-S	V profile	flood	Day	V	-	-	4	2515	0.0016
12	06-Apr-13	11:26	06-Apr-13	11:41	15	51.326	-3.173	51.323	-3.181	16	17	Transect N-S	V profile	flood	Day	V	-	-	3	2508	0.0012

13	06-Apr-13	11:53	06-Apr-13	12:08	15	51.307	-3.175	51.306	-3.183	12	12	Transect N-S	V profile	flood	Day	V	-	-	3	2522	0.0012

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
14	06-Apr-13	12:20	06-Apr-13	12:36	15	51.287	-3.180	51.286	-3.184	148	17	Transect N-S	V profile	flood	Day	V	-	-	7	2584	0.0027
15	06-Apr-13	12:47	06-Apr-13	13:02	15	51.270	-3.182	51.269	-3.190	15	15	Transect N-S	V profile	flood	Day	V	-	-	2	2697	0.0007
16	06-Apr-13	13:14	06-Apr-13	13:29	15	51.252	-3.182	51.250	-3.187	15	16	Transect N-S	V profile	flood	Day	V	-	-	1	2709	0.0004
17	06-Apr-13	13:41	06-Apr-13	13:56	15	51.234	-3.168	51.233	-3.177	14	15	Transect N-S	V profile	flood	Day	V	-	-	8	2734	0.0029
18	07-Apr-13	11:06	07-Apr-13	11:21	15	51.267	-3.120	51.267	-3.141	8	9	Parrett	0 m	flood	Day	V	4.63	25.65	1	2061	0.0005
19	07-Apr-13	11:33	07-Apr-13	11:49	15	51.266	-3.125	51.268	-3.141	9	10	Parrett	4 m	flood	Day	V	4.62	25.62	5	2357	0.0021
20	07-Apr-13	12:01	07-Apr-13	12:16	15	51.267	-3.125	51.267	-3.141	10	10	Parrett	0 m	flood	Day	V	4.69	25.61	4	2264	0.0018
21	07-Apr-13	12:29	07-Apr-13	12:44	15	51.266	-3.125	51.267	-3.136	10	11	Parrett	4 m	flood	Day	V	4.67	25.72	2	2591	0.0008
22	07-Apr-13	13:23	07-Apr-13	13:38	15	51.267	-3.123	51.268	-3.130	12	13	Parrett	7 m	flood	Day	V	4.66	25.85	6	2427	0.0025
23	07-Apr-13	13:52	07-Apr-13	14:07	15	51.268	-3.121	51.269	-3.126	13	14	Parrett	7 m	flood	Day	V	4.72	26.01	2	2495	0.0008
24	07-Apr-13	14:21	07-Apr-13	14:36	15	51.268	-3.123	51.268	-3.128	14	15	Parrett	7 m	flood	Day	V	4.72	26.06	4	2704	0.0015
25	07-Apr-13	14:47	07-Apr-13	15:02	15	51.268	-3.121	51.268	-3.126	15	16	Parrett	7 m	flood	Day	V	4.77	26.28	3	2795	0.0011
26	07-Apr-13	15:11	07-Apr-13	15:14	15	51.267	-3.121	51.267	-3.122	16	16	Parrett	4 m	flood	Day	V	4.8	26.52	2	3090	0.0006
27	07-Apr-13	15:37	07-Apr-13	15:52	15	51.268	-3.126	51.267	-3.135	17	17	Parrett	0 m	flood	Day	V	4.81	26.85	6	2587	0.0023
28	08-Apr-13	11:47	08-Apr-13	12:02	15	51.235	-3.165	51.232	-3.182	8	7	Hinkley Point C	0 m	flood	Day	V	4.89	26.13	2	1956	0.0010
29	08-Apr-13	12:14	08-Apr-13	12:29	15	51.235	-3.165	51.232	-3.180	8	9	Hinkley Point C	4 m	flood	Day	V	4.83	26.06	0	2592	0.0000

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
30	08-Apr-13	12:40	08-Apr-13	12:55	15	51.235	-3.166	51.233	-3.178	9	10	Hinkley Point C	0 m	flood	Day	V	4.91	26.07	4	2325	0.0017
31	08-Apr-13	13:06	08-Apr-13	13:21	15	51.235	-3.166	51.232	-3.176	10	9	Hinkley Point C	4 m	flood	Day	V	4.88	26.2	5	2932	0.0017
32	08-Apr-13	13:31	08-Apr-13	13:46	15	51.235	-3.164	51.233	-3.174	10	11	Hinkley Point C	0 m	flood	Day	V	4.83	25.94	3	2623	0.0011
33	08-Apr-13	13:54	08-Apr-13	14:10	15	51.235	-3.165	51.233	-3.175	11	12	Hinkley Point C	4 m	flood	Day	V	4.8	26.09	8	3035	0.0026
34	08-Apr-13	14:52	08-Apr-13	15:07	15	51.235	-3.164	51.233	-3.172	13	14	Hinkley Point C	7 m	flood	Day	V	4.91	26.43	2	2772	0.0007
35	08-Apr-13	15:19	08-Apr-13	15:35	15	51.235	-3.164	51.234	-3.171	14	15	Hinkley Point C	7 m	flood	Day	V	4.89	26.44	2	2756	0.0007
36	08-Apr-13	15:46	08-Apr-13	16:01	15	51.234	-3.165	51.233	-3.173	15	16	Hinkley Point C	7 m	flood	Day	V	4.87	26.45	1	2684	0.0004
37	09-Apr-13	12:40	09-Apr-13	12:56	15	51.219	-3.132	51.217	-3.150	4	5	Hinkley Point B	0 m	flood	Day	V	5.77	24	15	1748	0.0086
38	09-Apr-13	13:18	09-Apr-13	13:34	15	51.219	-3.130	51.218	-3.145	5	6	Hinkley Point B	0 m	flood	Day	V	5.63	24.52	10	2296	0.0044
39	09-Apr-13	13:48	09-Apr-13	14:03	15	51.221	-3.127	51.217	-3.139	6	7	Hinkley Point B	0 m	flood	Day	V	5.52	24.92	18	2532	0.0071
40	09-Apr-13	14:37	09-Apr-13	14:52	15	51.218	-3.131	51.218	-3.139	8	9	Hinkley Point B	4 m	flood	Day	V	5.25	25.76	2	2590	0.0008
41	09-Apr-13	15:07	09-Apr-13	15:22	15	51.218	-3.131	51.218	-3.137	9	10	Hinkley Point B	4 m	flood	Day	V	5.18	25.95	4	2543	0.0016
42	09-Apr-13	15:34	09-Apr-13	15:49	15	51.219	-3.131	51.218	-3.138	10	11	Hinkley Point B	4 m	flood	Day	V	5.23	25.87	1	2469	0.0004
43	09-Apr-13	15:59	09-Apr-13	16:14	15	51.219	-3.131	51.218	-3.138	11	12	Hinkley Point B	7 m	flood	Day	V	5.22	26.03	1	2229	0.0004
44	09-Apr-13	16:25	09-Apr-13	16:40	15	51.219	-3.130	51.219	-3.137	12	13	Hinkley Point B	7 m	flood	Day	V	5.18	26.1	0	2322	0.0000
45	09-Apr-13	16:48	09-Apr-13	17:03	15	51.219	-3.133	51.218	-3.140	13	14	Hinkley Point B	7 m	flood	Day	V	5.19	26.17	4	2381	0.0017

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
46	10-Apr-13	13:22	10-Apr-13	13:37	15	51.234	-3.166	51.231	-3.182	7	9	Transect S-N	V profile	flood	Day	V	5.12	26.05	1	2174	0.0005
47	10-Apr-13	13:51	10-Apr-13	14:06	15	51.250	-3.185	51.251	-3.200	29	12	Transect S-N	V profile	flood	Day	V	4.94	25.39	6	1845	0.0033
48	10-Apr-13	14:21	10-Apr-13	14:36	15	51.269	-3.184	51.269	-3.192	12	13	Transect S-N	V profile	flood	Day	V	4.98	25.63	5	1943	0.0026
49	10-Apr-13	14:47	10-Apr-13	15:02	15	51.285	-3.181	51.286	-3.186	14	16	Transect S-N	V profile	flood	Day	V	4.99	25.41	1	2120	0.0005
50	10-Apr-13	15:15	10-Apr-13	15:30	15	51.307	-3.176	51.306	-3.183	13	12	Transect S-N	V profile	flood	Day	V	5.06	26.17	5	2319	0.0022
51	10-Apr-13	15:43	10-Apr-13	15:58	15	51.325	-3.173	51.324	-3.177	17	18	Transect S-N	V profile	flood	Day	V	5.04	26.6	1	1930	0.0005
52	10-Apr-13	16:10	10-Apr-13	16:26	15	51.343	-3.167	51.343	-3.172	25	28	Transect S-N	V profile	flood	Day	V	5.07	27.02	1	2784	0.0004
53	10-Apr-13	16:39	10-Apr-13	16:54	15	51.363	-3.164	51.365	-3.167	25	22	Transect S-N	V profile	flood	Day	V	5.07	27.13	2	2915	0.0007
54	10-Apr-13	17:05	10-Apr-13	17:20	15	51.383	-3.158	51.385	-3.159	22	20	Transect S-N	V profile	flood	Day	V	5.22	27.43	12	2644	0.0045
55	11-Apr-13	13:31	11-Apr-13	13:46	15	51.381	-3.157	51.380	-3.182	10	18	Penarth	0 m	flood	Day	V	5.41	24.6	12	1586	0.0076
56	11-Apr-13	14:02	11-Apr-13	14:17	15	51.381	-3.157	51.380	-3.172	11	15	Penarth	4 m	flood	Day	V	5.25	24.76	5	2348	0.0021
57	11-Apr-13	14:27	11-Apr-13	14:42	15	51.381	-3.160	51.380	-3.170	12	15	Penarth	7 m	flood	Day	V	5.29	24.86	9	2600	0.0035
58	11-Apr-13	14:56	11-Apr-13	15:11	15	51.382	-3.157	51.381	-3.165	14	15	Penarth	0 m	flood	Day	V	5.35	25.08	18	2459	0.0073
59	11-Apr-13	15:24	11-Apr-13	15:39	15	51.382	-3.157	51.381	-3.162	15	17	Penarth	4 m	flood	Day	V	5.17	26.16	6	3058	0.0020
60	11-Apr-13	15:50	11-Apr-13	16:05	15	51.381	-3.156	51.380	-3.163	14	16	Penarth	7 m	flood	Day	V	5.16	26.24	2	3044	0.0007
61	11-Apr-13	16:14	11-Apr-13	16:29	15	51.382	-3.156	51.381	-3.161	16	18	Penarth	0 m	flood	Day	V	5.18	26.4	7	3029	0.0023

Stn.	Date Shot	Time Shot	Date Haul	Time haul	Dur (min)	Shot Lat	Shot Long	Haul Lat	Haul Long	Shot Depth	Haul Depth	Fishing Site	Fishing Depth	Tidal state	Day/ Night	Valid	Av Temp (°C)	Av Salinity (‰)	No. eels	Volume filtered (m^3)	Abundance (eels m^{-3})
62	11-Apr-13	16:37	11-Apr-13	16:52	15	51.382	-3.158	51.381	-3.162	19	19	Penarth	4 m	flood	Day	V	5.16	26.68	9	2838	0.0032
63	11-Apr-13	17:02	11-Apr-13	17:17	15	51.382	-3.155	51.382	-3.159	19	21	Penarth	7 m	flood	Day	V	5.17	26.94	3	2655	0.0011

Appendix C Summary of the number of eels caught per fishing tow

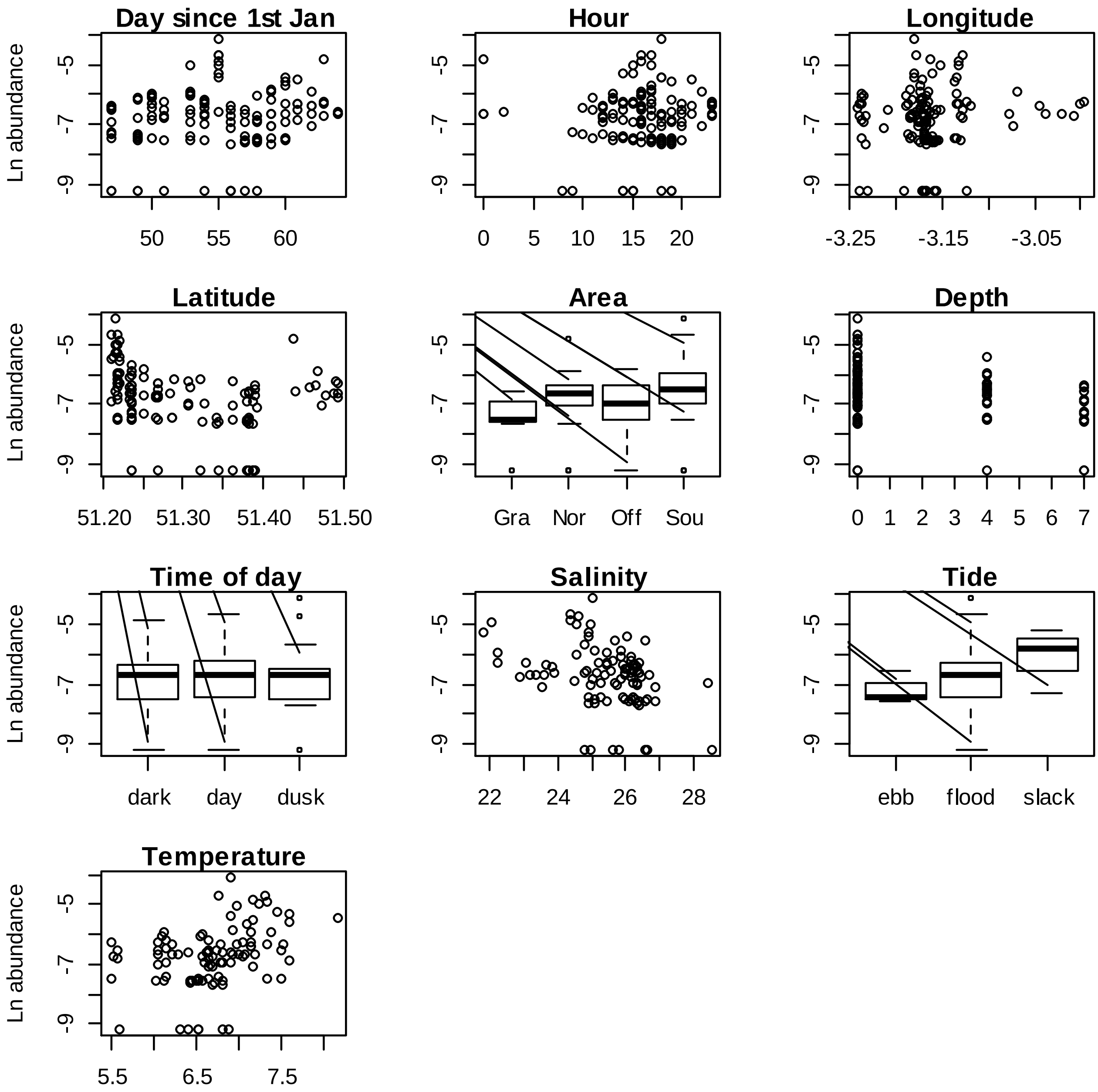
Count of fishing tows (samples) containing a given number of eels for the February 2012 (Hink 1/12), February 2013 (Hink 1/13) and April 2013 (Hink 2/13) surveys (*e.g.* in February 2012, 30 of the 128 fishing tows contained only 1 eel, but in February 2013, only 2 of the 130 fishing tows contained 1 eel). The 2012 data are taken from BEEMS Technical Report TR-S211.

Number of eels in the sample	Number of fishing tows		
	Hink 1/12	Hink 1/13	Hink 2/13
0	11	8	3
1	30	2	10
2	19	5	10
3	24	8	5
4	15	3	6
5	10	7	6
6	2	10	4
7	3	6	2
8		1	6
9	2	4	2
10	3	6	1
11	1	11	1
12	1	2	3
13		2	
14	1	2	
15		5	1
16		6	
17		1	
18	1	3	2
19	1	1	
20	1	5	
21		2	
22		1	
23		4	1
24	1	2	
26	1	4	
27		1	
28		2	
29		2	
30		1	
31		1	
32		1	
33		1	
34		2	
35		2	
37		1	
43	1	1	

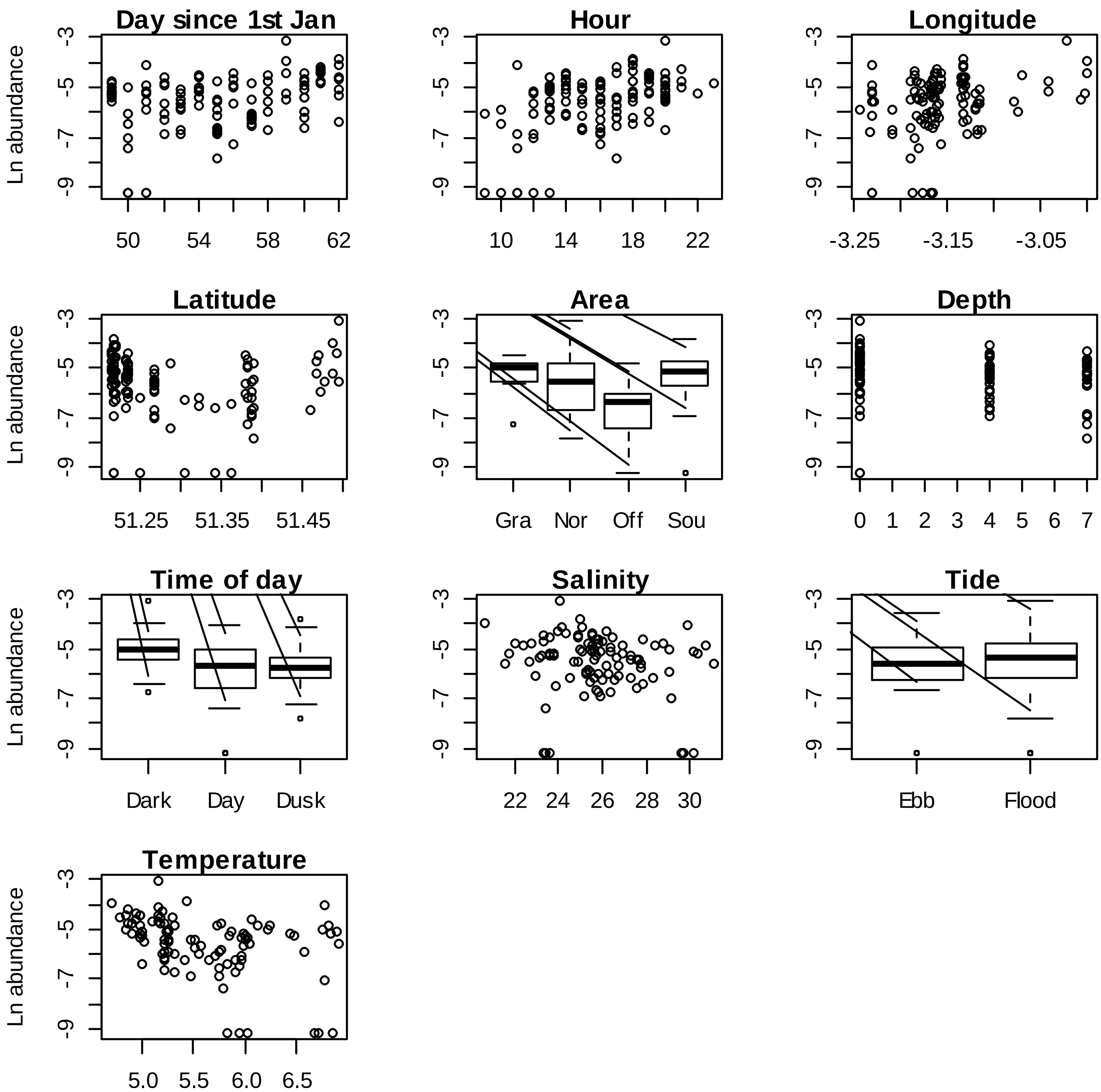
45		1	
55		1	
63		1	
125		1	
Total	**128**	**130**	**63**

Appendix D Plots of *ln* eel abundance against explanatory variables

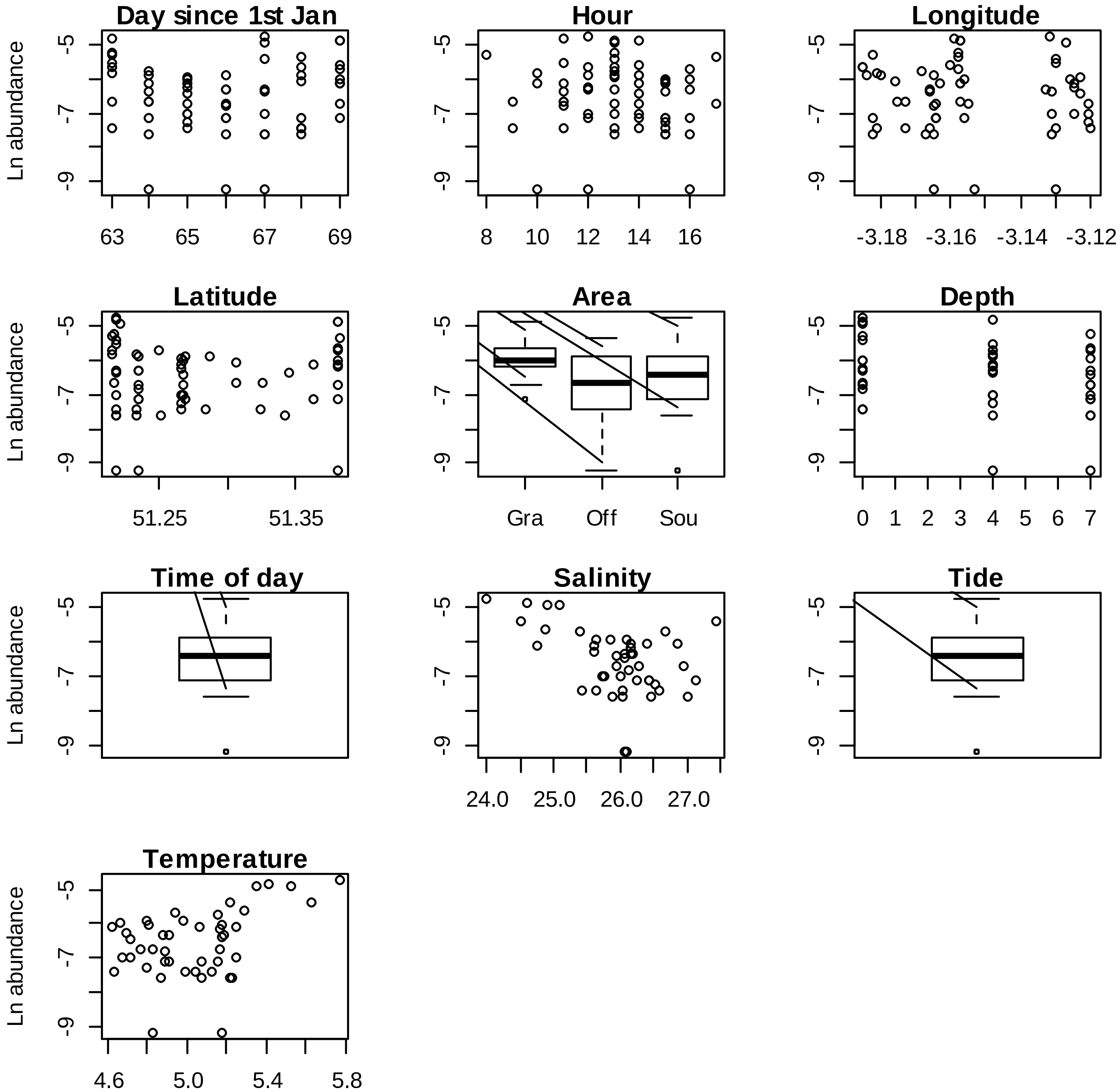
D.1 Plots of *ln* eel abundance against explanatory variables for the February 2012 survey



D.2 Plots of *ln* eel abundance against explanatory variables for the February 2013 survey



D.3 Plots of *ln* eel abundance against explanatory variables for the April 2013 survey

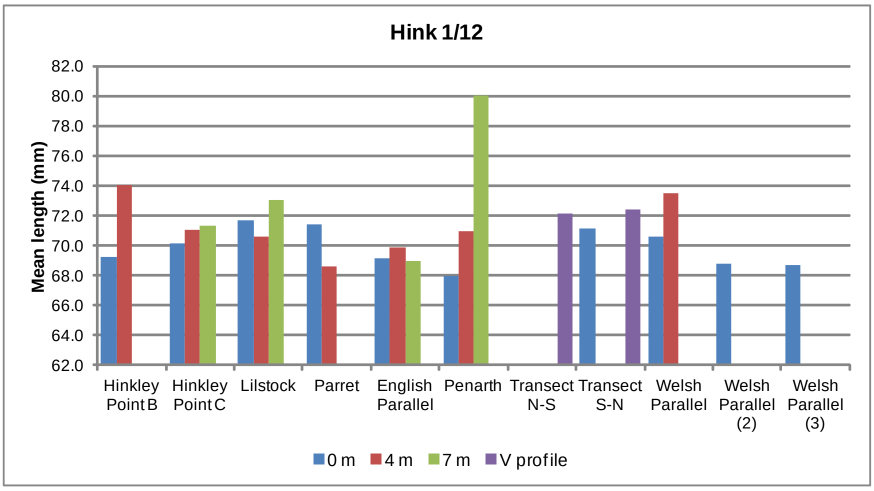


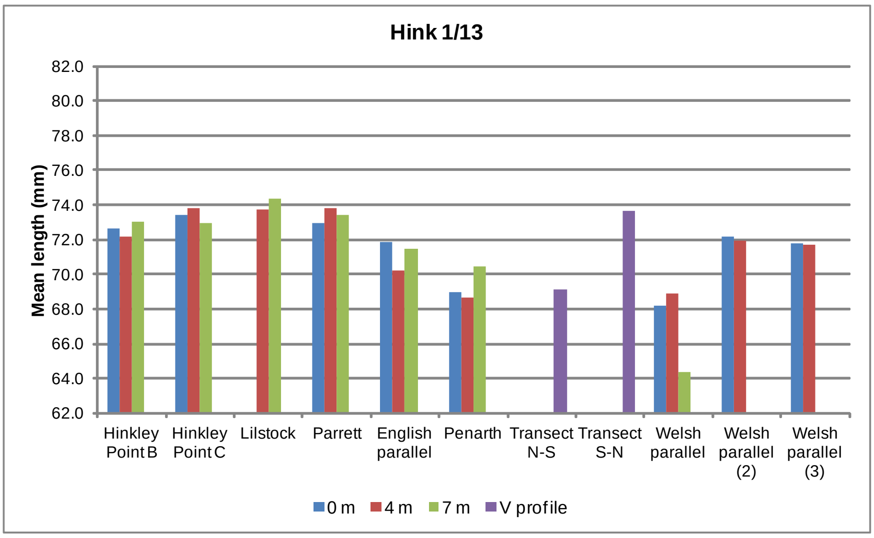
Appendix E Eel length

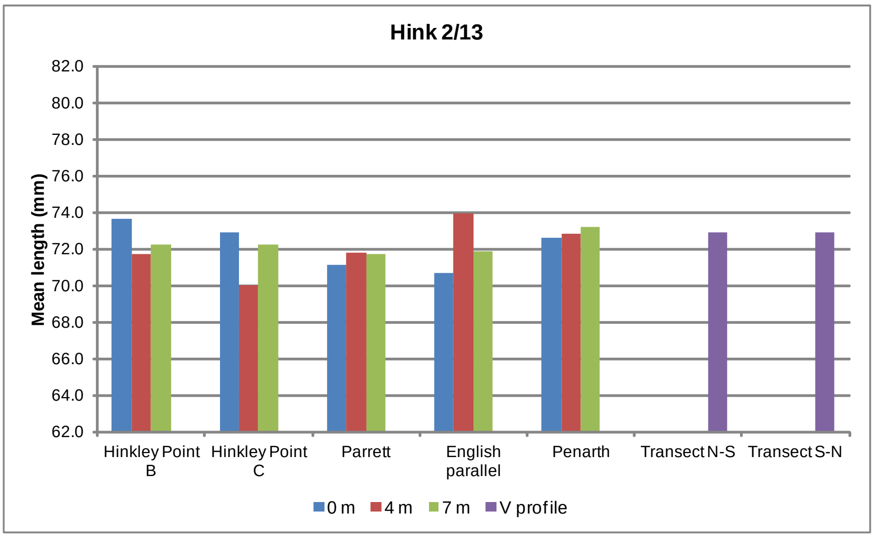
E. 1 Mean, minimum and maximum length (mm) of eels by fishing site, area, depth, time of day, temperature and salinity during all three surveys. *n* = number of fish measured

	February-March 2012				February-March 2013				April 2013			
	Mean	**Min**	**Max**	***n***	**Mean**	**Min**	**Max**	***n***	**Mean**	**Min**	**Max**	***n***
Site												
Hinkley Point B	69.4	62	79	41	72.7	62	82	361	73.2	65	82	55
Hinkley Point C	70.7	64	78	50	73.3	61	84	289	71.4	63	77	27
English Parallel	69.2	60	77	202	71.3	55	82	376	72.7	64	81	79
Lilstock	71.6	67	79	30	73.9	63	83	109	-	-	-	
Parrett	69.8	67	74	12	72.8	60	84	113	71.5	65	79	35
Penarth	71.9	63	81	13	69.5	58	81	155	72.8	60	85	71
Transect NS	72.1	65	80	14	69.1	61	77	84	72.9	65	80	34
Transect SN	71.9	62	78	68	73.6	67	82	24	72.9	67	78	33
Welsh Parallel 1	70.9	63	80	17	68.2	59	82	74	-	-	-	
Welsh Parallel 2	68.9	61	79	50	72	63	80	104	-	-	-	
Welsh Parallel 3	68.5	63	72	20	71.7	60	81	241	-	-	-	
Area												
North Bank gravel	71.9	63	81	13	69.5	58	81	155	72.8	60	85	71
North Bank inshore	68.8	61	79	87	71.3	59	82	419	-	-	-	0
Offshore	71.9	62	80	82	70.2	61	82	108	72.9	65	80	67
South Bank inshore	69.8	60	80	335	72.5	55	84	1248	72.5	63	82	196
Time of day												
Day	70.3	62	81	252	71.3	55	84	864	72.6	60	85	334
Dark	69.8	60	79	163	72.3	60	84	848	-	-	-	
Dusk	69.8	64	81	102	72.2	61	82	218	-	-	-	
Depth (m)												
Depth 0	69.5	60	80	381	71.8	55	84	1056	72.6	60	85	117
Depth 4	70.6	63	78	62	72.1	60	84	441	72.7	63	81	91
Depth 7	72.8	67	81	19	72.4	61	83	325	72.2	61	82	59
Salinity (‰)												
Sal ≤ 25.5	69.4	61	81	321	72.2	55	84	975	73.5	65	85	94
Sal > 25.5	70.8	60	81	136	72.1	60	83	726	71.9	60	82	128
Temperature (°C)												
Temp ≤ 6.7	71	62	81	107								
Temp > 6.7	69.4	60	81	350								
Temp ≤ 5.5					72.1	55	82	1132				
Temp > 5.5					73.5	60	84	569				
Temp ≤ 5.0									71.7	63	80	74
Temp > 5.0									73	60	85	148

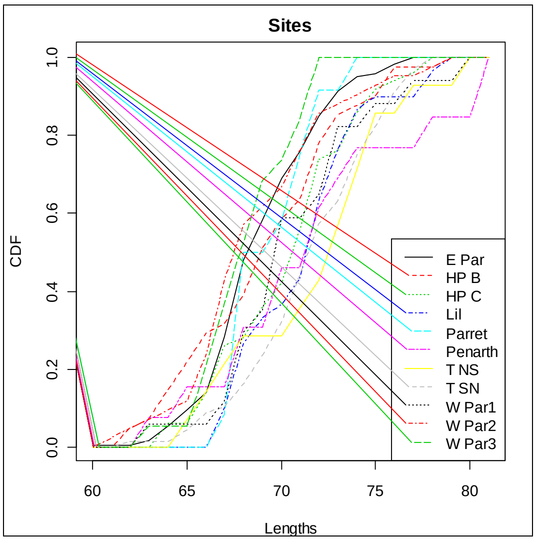
E. 2 Mean length (mm) by site and depth for eels sampled in February 2012 (Hink 1/12), February 2013 (Hink 1/13) and April 2013 (Hink 2/13)

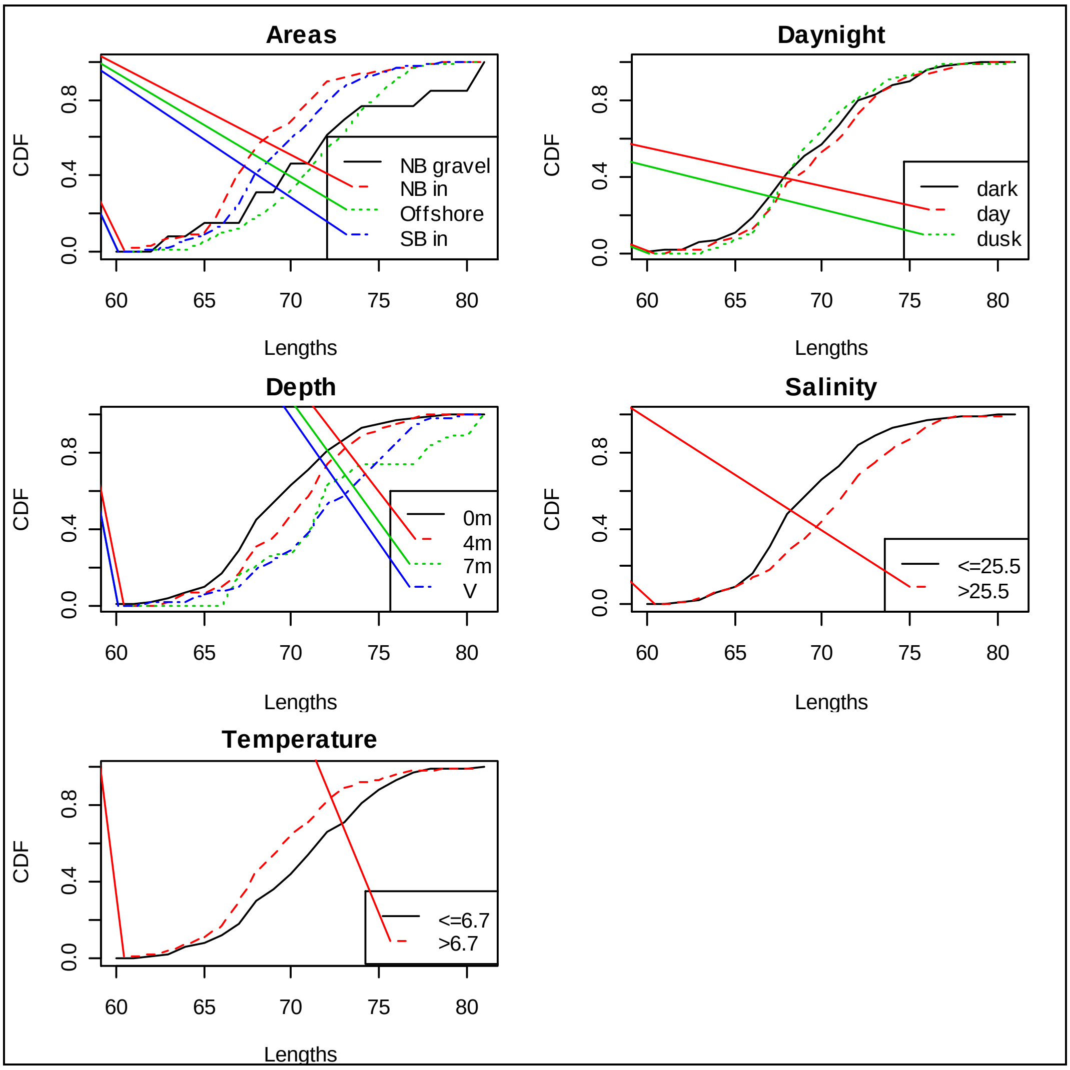




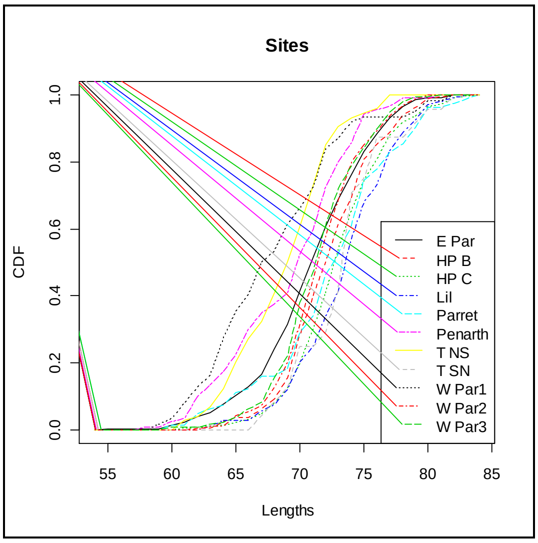


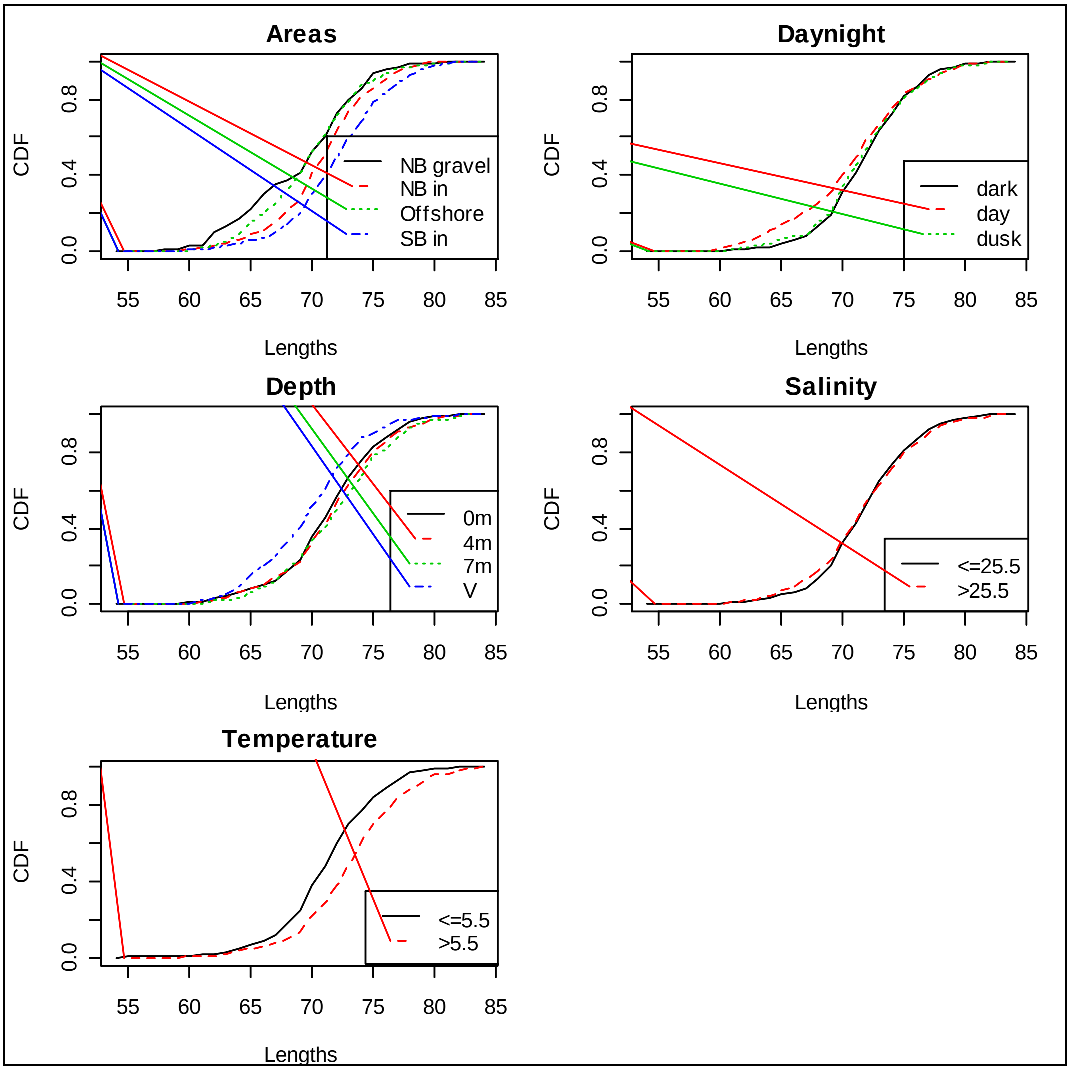
E. 3 Cumulative Distribution Functions (CDFs) of eel length by (top panel) site and (bottom panel) area, time of day, depth, salinity and temperature, in February-March 2012. The CDF is the proportion of the sample that is less than or equal to any particular length



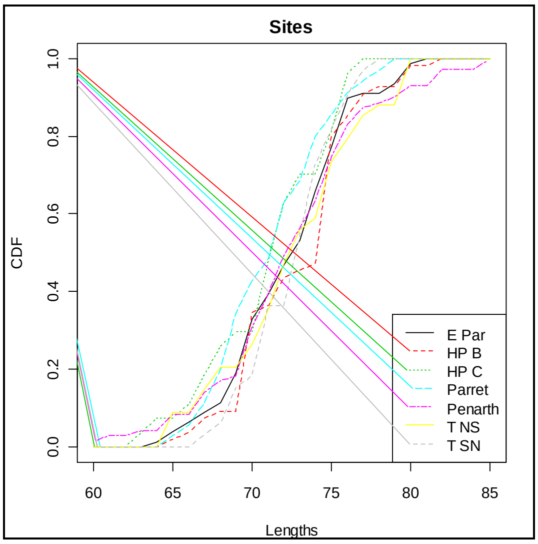

Areas
CDF
Lengths
NB gravel
NB in
Offshore
SB in
Daynight
dark
day
dusk
Depth
0m
4m
7m
V
Salinity
<=25.5
>25.5
Temperature
<=6.7
>6.7

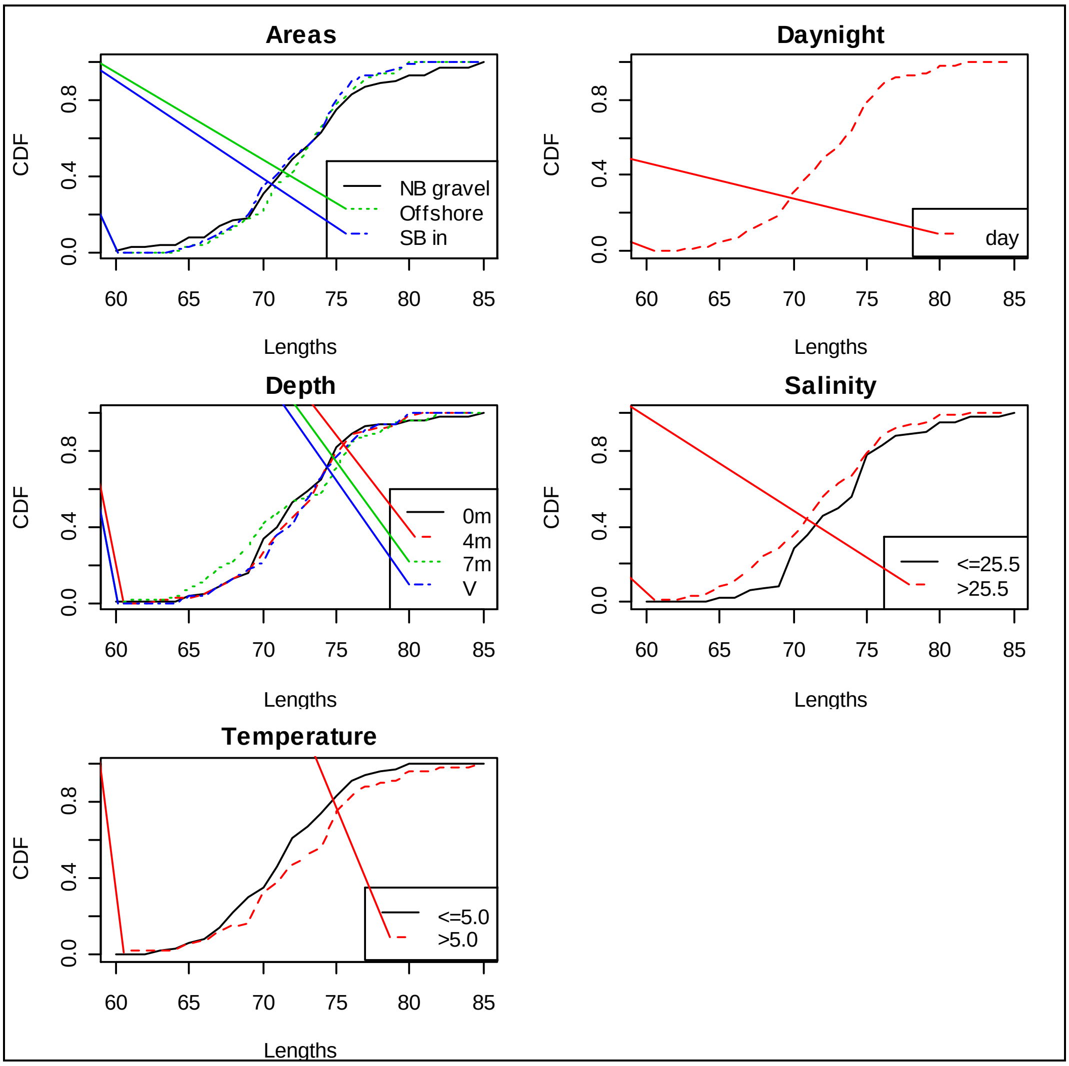
E. 4 Cumulative Distribution Functions (CDFs) of eel length by (top panel) site and (bottom panel) area, time of day, depth, salinity and temperature, in February-March 2013. The CDF is the proportion of the sample that is less than or equal to any particular length





E.5 Cumulative Distribution Functions (CDFs) of eel length by (top panel) site and (bottom panel) area, time of day, depth, salinity and temperature, in April 2013. The CDF is the proportion of the sample that is less than or equal to any particular length





Appendix F Eel life history stages

Definition of the eel life history stages, based on Elie *et al*. (1982)

A – Stage IV

Pronounced swelling of the abdomen (from the pectoral fins to the anus). The height of the body at the anus is always greater than 3 mm. The caudal colouring (caudal spot) is already shown at this stage as several spots of melanotic deposit.

B – Stage V

This is broken down into 2 stages:

Stage Va
The caudal spot remains localised at the tip of the caudal fin without reaching the actual body, either dorsal, lateral or abdominal. No other superficial pigmentation exists either at the beginning or the end of this stage

Stage Vb
Early Stage Pigmentation
Head: presence of a spot of cerebral colouration, either deep or superficial. Body: slight extension of pigmentation at the dorsal edge of the animal, at the tip of the caudal region.

Late Stage Pigmentation
Head: the cerebral spot is more developed and has taken its heart-like shape; the superficial rostral pigmentation does not exceed the posterior part of the heart-shaped spot. Body: at the tip of the caudal region the pigmentation increases in two areas: the dorsal edge and the lateral dorsal area. It should however be noted that the lateral (distal) part of the caudal area can, at this stage, show large superficial medio-lateral melanophores, a phenomenon already noted by Panu (1929) and at an earlier stage than that described by Strubberg (1913).

C. Stage VI

Stage VI_{A0}
This stage was created by Elie (1979) as the passage between stage V_B and VI_{A1} was found to be too brutal and doesn't correspond with the dynamics of the phenomenon of pigmentation. In effect, the superficial melanisation develops not only from the caudal area but also from the rostral area (snout).

Early Stage Pigmentation
Head: the superficial rostral pigmentation exceeds the heart-shaped spot and characterised by a melanotic deposit more or less intense (from 1 to 3 melanophores lower than the heart-shaped spot). Body: the pigmentation at the dorsal edge reaches the distal part of the anal area. It appears in two ways, at the base of the dorsal fin, either by a fine, continuous line of melanophores or by very spaced melanophores.

Late Stage Pigmentation
Head: the heart-shaped spot is previously completed by a simple semi-circle of large star-shaped melanophores. The pigmentation of the final range of gills appears. Body: the dorsal edge appears as a pigmented line to the anus;the dorso-lateral pigmentation is always relegated into the last half of the caudal area, the pigment is deposited clearly along the myosepts; the pigmentation medio-lateral is developed in almost every individual in the caudal area. At this stage the junction between the superficial rostral and caudal pigmentation is not yet established.

Stage VI_{A1}
Early Stage Pigmentation

Head: the superficial rostral pigmentation exceeds the cerebral spot to join the pigmentation at the posterior dorsal edge. This dorsal junction appears as a loose line of melanophores; the cerebral spot has taken on its heart-shaped appearance, but doesn't have the previous semi-circle of large star-shaped melanophores.

Late Stage Pigmentation
Head: the superficial pigmentation on the dorsal edge of the animal appears as a continuous line of melanophores; the cerebral spot is complete, it is composed of the heart-shaped spot completed at the front by a semi-circle of star-shaped melanophores, arranged in two rows; the two rows of posterior gills are very melanotic, the others less so. Body: the dorso-lateral pigmentation is developed as far as the anus and in rare cases can slightly exceed it; there are several ventro-lateral - melanotic spots at the tip of the caudal region; the medio-lateral pigmentation is well developed and can sometimes reach the caudal half of the area. This stage is characterised by the continuous superficial pigment along the entire dorsal edge of the animal. The junction between the rostral and caudal pigment is established.

Stage VI_{A2}
From this moment, all the areas being pigmented increase their melanisation. The determination of the state of pigmentation in early and late stage development is much more subtle. The latter are mainly marked by the difference in intensity of pigmentation in each area.
Early stage pigmentation
Head: the cerebral spot is complete and appears in every case; all gill rows are melanised; the line of dorsal pigmentation thickens laterally. Body: the dorso-lateral pigmentation is developed in the area between the start of the dorsal fin and the anus; at this time there clearly exists deep pigmentation, arranged in multiple lines along the heart, liver, stomach and intestines as far as the anus; the ventro-lateral pigmentation is developed in the last third of the caudal area; the melanisation of the medio-lateral line reaches the anus
Late stage pigmentation
Head: the melanisation intensifies in the cerebral areas mentioned in early stage. Body: The melanisation of the dorso-lateral region reaches the start of the dorsal fin; the pigmentation of the ventro-lateral region reaches the caudal half of the area; the pigmentation of the medio-lateral line exceeds the anus in most cases; the deep melanisation which exists along the internal organs is very clear. Stage VI_{A2} should be considered as the limit of metamorphosis as the animal begins to feed itself again during this time.

Stage VI_{A3}
The melanisation of the dorso-lateral, medio-lateral and ventro-lateral areas increases and develops towards the front of the animal. The states of pigmentation marking the beginning and end of this stage are not easy to detect. Head: the cerebral spot becomes more visible than at the earlier stage due to the greater intensity of the superficial rostral pigment. Body: the dorso-lateral pigment is developed in the area between the pectorals and the start of the dorsal fin; the ventro-lateral melanisation reaches the anus or the area immediately behind it; the medio-lateral pigment appears in the area between the start of the dorsal fin and the pectoral fins; the lines of melanophores along the internal organs are very visible

Stage VI_{A4}
In spite of the density of the superficial pigment, the melanisation arranged in myosepts is still very visible on the whole body. Here again, the states of pigmentation at early and late stage are difficult to define in a simple way. However, differences exist in the intensity and extent of superficial pigmentation in the ventro-lateral area between the pectoral fins and the anus. Head: the cerebral spot is still visible but largely covered by the superficial rostral pigment. The latter almost entirely obstructs the un-pigmented circle at the centre of the cerebral spot; spots of melanisation appear at the base of the nasal tubes; the upper edge of the jawbone is pigmented as far as the corner of the mouth; the inside of the pectoral peduncle is melanised in most cases. Body: the dorso-lateral pigment underlines all the myosepts, it is also intermyoseptal in the area between the pectoral fins and the dorsal fin; the ventro-lateral pigmentation extends past the anus. It can also appear as several melanophores where the dorsal fin starts. This ventro-lateral pigmentation in the area in front

of the anus, appears as an incomplete deposit of melanin along the myosepts. There is neither doubling up of series of myosepts, nor intermyoseptal deposit in this area.

Stage VI_B

At this stage, the animal clearly resembles the adult, some areas, however, are still transparent, but the internal organs (heart, liver, stomach, intestine) become less easily noticeable. Head: the cerebral spot is not very visible, masked by superficial pigmentation; the pigmentation on the upper edge of the upper and lower jawbones appears; the internal base of the pectoral fins appears clearly pigmented but loose. Body: the pigmentation of the dorso-lateral area is diffused, as is that of the ventro-lateral area, but the myoseptal arrangement of the melanophores can clearly be seen in the front half of the area between the pectoral fins and the start of the dorsal fin; the ventral edge, in the caudal area, and the abdomen are made opaque by the generalised development of the guanophores and yellow pigmented cells; the internal organs are almost invisible.

D. Stage VII or elver

This stage is marked by the generalised development of the yellow pigmented cells, and by the loss of transparency which only remains in a few cases in the caudal area. The abdominal cavity is silvery and the digestive tract no longer visible. The end of this stage is marked by the beginning of the development of the gonads which enables sex determination by histological examination at a size which varies on the French Atlantic coast between 20 and 30 cm.