HINKLEY POINT C PERMIT VARIATION

EPR/HP3228XT/V004

Technical Brief: TB004

Accounting for entrainment losses and difference in drum screen size.

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INTRODUCTION

In TR456 Ed2 (BEEMS, 2019), the cumulative impact of fish losses associated with the cooling water intake system at Hinkley Point C (HPC) from both impingement and entrainment have not been assessed.

Impingement at HPC is defined as an individual coming into contact with, but failing to pass through, the 5mm mesh aperture drum and band screens that screen the intake forebay from the remaining cooling water intake system of the power station. Individuals impinged upon the drum screen will be recovered by rotating buckets and washed into the Fish Recovery & Return (FRR) system.

Entrainment at HPC is defined as individuals passing through the 5mm mesh aperture drum and band screens and entering the cooling water intake system. Individuals entrained will be subject to temperature, pressure and mechanical stressors, as well as potentially chlorination if in use at the time of entrainment.

Only the impinged fraction is assessed in TR456 Ed2 however, this does not account for the change in impingement associated with amending the drum screen size from 10mm at Hinkley Point B (HPB) (which the current impingement data is sourced from) to 5mm at HPC. Entrainment losses were previously considered in TR148 (BEEMS, 2011) by estimating the numbers of fish eggs and larvae entering the intake, but no size analysis was undertaken to apportion between those which would pass through the 5mm mesh aperture of the drum screens and band screens.

Both the entrainment losses, and change in impingement/entrainment fraction need to be accounted for within the quantitative assessment to inform the Habitats Regulations Assessment (HRA).

An approach to integrating entrainment losses into the assessment is presented below, with worked examples for all relevant species. The process followed is set out in the flowchart in Figure 1 below.

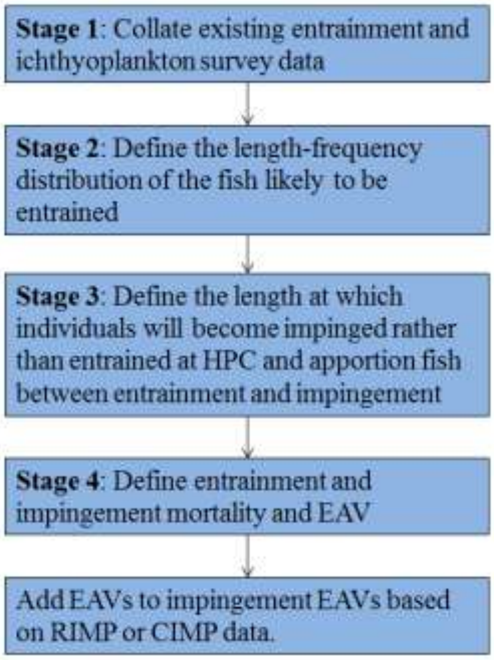

Figure 1: Flowchart of the process for incorporating additional losses at HPC due to entrainment and impingement from the change in screen size from 10mm to 5mm.

Stage 1 - Collate existing entrainment and survey data

In TR148, entrainment is estimated for HPC based on ichthyoplankton surveys conducted in 2008 and 2009. These estimates were accepted by the Environment Agency (EA) during the Development Consent Order (DCO) process and have not been revised since. Furthermore, the removal of the Acoustic Fish Deterrent (AFD) is not considered to influence the rates of entrainment of these individuals, given their small size and limited swimming capability. We have not attempted to confirm whether these entrainment rates are appropriate or representative, or to verify the method used to estimate the entrainment rates from the underlying ichthyoplankton survey data. The entrainment rates from TR148 are therefore, considered without amendment. It should be noted however, that as the HPC intake flow rates have changed since the production of TR148 some amendment may be required to account for this. Also, it should be noted that the entrainment rates are only for February to June, and larval and small juvenile fish of many species will be present all year round and in differing densities.

Entrainment rates as presented within TR148 are reproduced in Table 1 below for the species which are being assessed by the EA for the AFD removal permit variation. For the species where no entrainment estimates are presented in TR148, some individuals may be at entrainment risk at HPB, and therefore impingement and entrainment risk at HPC. Juveniles and larvae of species such as whiting, Atlantic cod, brown shrimp and blue whiting are also likely to enter the intake, but at present there is no data presented upon which to base quantitative estimates. This may be a result of the ichthyoplankton sampling failing to capture the individuals present. Specific consideration is given to the cases of European eel, river and sea lamprey and twaite and allis shad below, as they are likely to be at entrainment risk and/or may have increased impingement rates from the change in screen size between 10mm to 5mm. For the remaining species, such as salmonids and thornback ray, they are not expected to be present within the marine environment at sizes which would be at risk of entrainment through a 10mm mesh size.

Other surveys of egg, larval and juvenile fish species have been conducted for the project beyond those detailed in TR148. Pisces Conservation Ltd. conducted monthly plankton sampling in the intake forebay of HPC between 1982-1995 and 2006-2009, using 700 µm and 150 µm mesh nets. It was not possible to measure or estimate the volume of water sampled during each survey as the nets quickly clogged with silt and had to be withdrawn. The enumerated entrainment of egg, larval and juvenile fish species captured cannot therefore, be compared with a sampled volume of water and are of limited use in estimating entrainment rates associated with a specific rate of abstraction. Furthermore, no size data is available for the individuals sampled. The species captured by the plankton sampling were as follows:

- Gobies (sand goby, painted goby, transparent goby)
- Flatfish (European plaice, European flounder, Dover sole)
- Gadoids (Whiting, pout)
- Clupeids (European sprat, Atlantic herring)
- Sandeel species
- Mullet species
- Common dragonet
- Common seasnail
- Cuckoo wrasse
- European eel
- Rock gunnel
- Reticulated dragonet

Furthermore, APEM Ltd. conducted zooplankton trawls from November 2008 to July 2009 in Bridgwater Bay for HPC, including at the HPC intake location. The sampling used 500 µm mesh nets to capture zooplankton. These surveys captured very small numbers of larval and juvenile fish and as the methods are not targeted towards sampling ichthyoplankton, they are therefore of limited use in estimating entrainment rates as they may underestimate ichthyoplankton densities within the water column. The species captured by the zooplankton trawls were as follows:

- Dover sole
- European seabass
- European sprat
- Reticulated dragonet
- Sand goby
- Transparent goby

Therefore, of the species being assessed for the project in Table 1 for which entrainment rates are not provided, both whiting and European eel have been found from larval surveys within the intake indicating they are both likely to be at risk of entrainment.

Table 1: Predicted entrainment rates (February to June) at HPC for the species being assessed for the permit variation application, estimated from icthyoplankton surveys conducted at HPC as presented in TR148.

Species	Number of eggs	Number of larvae	Notes
European sprat	0	7,114,303	
Whiting	-	-	No estimate provided
Dover sole	9,461,839 (+potential 450,281 Soleidae eggs)	1,929,208 (+potential 369,308 Soleidae larvae)	
Atlantic cod	-	-	No estimate provided
Herrings (used for Atlantic herring)	0	414,615	Herring eggs adhere to the bed which would mean they are not detected within icthyoplankton trawls. Their bed adhesion also means they are unlikely to be drawn into the intake prior to hatching. This data is used for the Atlantic herring *Clupea harengus* assessment
European seabass	47,282,931	41,981,786	
European plaice	0	3,322,735	
Thornback ray	-	-	No estimate provided
Blue whiting	-	-	No estimate provided
European eel	-	-	No estimate provided
Twaite shad	-	-	No estimate provided
Allis shad	-	-	No estimate provided
Sea lamprey	-	-	No estimate provided
River lamprey	-	-	No estimate provided
Atlantic salmon	-	-	No estimate provided
Sea trout	-	-	No estimate provided
Brown shrimp	-	-	No estimate provided
Gobies	0	10,351,234	Goby eggs adhere to the bed which would mean they are not detected within icthyoplankton trawls. Their bed adhesion also means they are unlikely to be drawn into the intake prior to hatching. This data is used for the sand goby *Pomatoschitus minutus* assessment
Sandeels	0	9,075,949	Sandeel eggs adhere to the bed which would mean they are not detected within icthyoplankton trawls. Their bed adhesion also means they are unlikely to be drawn into the intake prior to hatching. This data is used for the lesser sandeel *Ammodytes tobianus* assessment.
European flounder	0	2,711,333	
Sand smelt	-	-	No estimate provided

European eel *Anguilla anguilla*

- The data presented in TR148 omits a key species at entrainment and impingement risk, European eel, given their elongate body shape and difficulty in detecting via conventional survey methods. SPP073/S (BEEMS, 2012) discusses entrainment of glass eels but does not quantify entrainment numbers and is not in a format that can be integrated into the current assessment framework.

  Glass eel densities within the water column on the flood tide were available from 2012 and 2013 at the proposed HPC intake location, during the glass eel migratory period. The Environment Agency reviewed the raw data (from TR S-211 and TR274) to determine glass eel densities (Table 2). These figures are slightly different to those presented by the applicant, likely to be due to the Environment Agency approach of pooling of all relevant trawl data to produce the mean glass eel density, rather than taking the mean of the means for the three separate trawl periods.

Survey dates	**European eel mean density (individuals/m^3) for pooled trawl data**
February-March 2012 February-March 2013 April 2013	0.00309

Table 2. Glass eel densities from surveys at proposed HPC intake location as determined from raw trawl data in TR S-211 and TR274.

- The glass eel migratory period in the Bristol Channel is likely to be between mid-February and mid-May, with glass eels predominantly migrating on the flood tide, and holding to the bed or channel margins on the ebb tide. The Environment Agency estimated the number of glass eels entering the intake as:

$$E = D \times A \times T$$

Where:

E = entrapment number; the number of glass eels entering the intake

D = glass eel density; mean of February-March 2012, February-March 2013 and April 2013 surveys at proposed HPC intake site only.

A = abstraction rate

T = time period

- For HPC, T is 45 days, expressed as seconds (there are 90 days between mid-February and mid-May but this is divided by two, to account for glass eel migration taking place primarily on the flood tide):

$$E = 0.00309 \text{individuals } m^{3} \times 131.86\ m^{3}s^{-1} \times 3{,}888{,}000\ s$$

E = 1,581,697 glass eels entrained per annum.

River lamprey *Lampetra fluviatilis and* sea lamprey *Petromyzon marinus*

Of the other species being assessed by the EA for the AFD removal permit variation, river lamprey and sea lamprey are also likely to be under-represented within the baseline impingement datasets given their elongate body shape and small size, as many will pass through the 10mm mesh at HPB. The only river lamprey individuals recorded within the Comprehensive Impingement Monitoring Program (CIMP) dataset were between 235-250mm standard length, and the sea lamprey individuals recorded were between 200-800mm. Given their recorded lengths, the river lamprey individuals are likely to be sub-adults in their marine resident/foraging phase, and sea lamprey individuals may be either sub-adults or returning spawners.

Sea and river lamprey of shorter lengths will be able to pass through a 10mm screen and so would not have been recorded by the impingement monitoring conducted for the CIMP and Regular Impingement Monitoring Program (RIMP). These individuals will be present within the Severn Estuary and Bristol Channel, as they leave their home rivers as juvenile transformers to spend a number of years feeding in the estuarine and marine environment. These may either pass through the 5mm screen proposed for HPC or be impinged upon the screen (only impingement likely in the case of sea lamprey).

Given the parasitic behaviour of this species, their number, their attachment to larger fish and their migratory behaviours, they are also likely to be under-represented within the ichthyoplankton dataset used to define entrainment estimates in TR148.

The numbers of river lamprey and sea lamprey entering the intake is likely to be larger than estimated from the HPB CIMP data due to the unaccounted entrainment fraction and potential for increased impingement from the change in screen size from

10mm to 5mm, but at present there is no data presented upon which to base quantitative estimates.

Twaite shad *Alosa fallax* and allis shad *Alosa alosa*

Similarly to river and sea lamprey, both twaite and allis shad may be present in the marine environment at HPC at sizes which could pass through a 10mm mesh, as they leave the rivers as juveniles to enter estuaries at lengths of less than 50mm. The smallest size recorded as impinged upon the 10mm screens at HPC from the CIMP was ~47mm SL (plus a ~12mm SL individual considered to have been either a mis-identification or a washout from the river). This indicates the presence of smaller individuals in Bridgwater Bay, though many of this size could pass through a 10mm mesh given their fineness ratios are likely to be similar to European sprat or Atlantic herring (4.75 from Turnpenny (1981)).

Few would be likely to pass through a 5mm mesh however, and therefore impingement rates of this species are likely to increase as a result of the change in mesh size, but at present there is no data to base quantitative estimates.

Stage 2 – Define the length-frequency distribution of the fish likely to be entrained

The length-frequency distribution of the fish predicted to be entrained will generally be a smaller fraction than the individuals recorded as impinged upon the screens at HPB. This is because it will have been these smaller individuals which would have passed through the HPB screens and therefore not been recorded by the impingement monitoring.

The ichthyoplankton monitoring conducted and used to develop the entrainment estimates in TR148 is reported in TR083 (BEEMS, 2010a) and TR083a (BEEMS, 2010b) but no length frequency data is available. Length-frequency data is available for glass eels from TR274, as reproduced in Figure 1 below.

Table 3 documents the likely length range of the fish which could have been entrained at HPB and not detected in the HPB impingement monitoring data. The smallest length at risk of entrainment through a 10mm screen is set as the size at hatching of the species where appropriate, as some individuals would have just hatched when they entered the intake. The largest length at risk of entrainment through a 10mm screen is set based on the largest size at which an individual could freely pass through a 10mm screen using the fineness ratio data.

In the absence of length-frequency distribution information for the species from the ichthyoplankton surveys, it is considered appropriate to uniformly distribute the fish predicted to be entrained between their length at hatching and the largest length at which an individual could freely pass through a 10mm screen, on a precautionary basis. Fish egg size can be estimated also, but it is likely that all these will be entrained.

With the development of a length-frequency distribution of the fish entering the intake, these will then be apportioned between entrainment and impingement using the fineness ratios and passable mesh sizes at HPC developed in Stage 3. The entrainment estimates defined in Stage 1 will be multiplied by the proportion impinged or entrained to provide estimates of additional impingement and entrainment numbers.

Table 3: Length range of fish which could have been entrained at HPB and not detected in the HPB impingement monitoring data, to apportion between impingement and entrainment for HPC.

Species	Minimum size; Size at hatching (SL, mm)	Maximum size; Largest size for free passage through 10mm mesh (SL, mm)
European sprat	2.55*	47.5
Whiting	3.2*	39.2
Dover sole	2.5*	27.4
Atlantic cod	3.3*	39.2
Herrings (used for Atlantic herring)	4*	47.5
European seabass	3.61*	36.7
European plaice	6*	27.4
Thornback ray	NA – individuals hatch at around 110-130mm TL therefore unlikely to be at risk of passage through a 10mm screen	
Blue whiting	2*	39.2
European eel	See Figure 1 for length-frequency distribution data for use	
Twaite shad	~40 (estimate of minimum size at entry to estuarine environment)	47.5
Allis shad	~40 (estimate of minimum size at entry to estuarine environment)	47.5
Sea lamprey	~155**** (estimate of minimum size at entry to estuarine environment)	180
River lamprey	~65 (estimate of minimum size at entry to estuarine environment)	180
Atlantic salmon	NA – unlikely to be present in the marine environment at a size at risk of passage through a 10mm screen	
Sea trout	NA – unlikely to be present in the marine environment at a size at risk of passage through a 10mm screen	
Brown shrimp	2.30***	68.8
Gobies	3.00*	57
Sandeels	4.00*	102
European flounder	2.30*	27.4
Sand smelt	6**	52.9

*Russell, F.S. (1976) The eggs and planktonic stages of British marine fishes. Academic Press, London, UK. 524 p.
**Faria, A. M., Goncalves, E. and Borges, R. (2014) Critical swimming speeds of wild-caught sand-smelt Atherina presbyter larvae. Journal of Fish Biology 85: 953-959.
***http://www.marlin.ac.uk/biotic/browse.php?sp=4599

**** Bird, D. J., Potter, I. C., Hardisty, M. W. and Baker, B. I. (1994) Morphology, body size and behavior of recently-metamorphosed sea lampreys, Petromyzon marinus, from the lower River Severn, and their relevance to the onset of parasitic feeding. Journal of Fish Biology 44: 67-74.

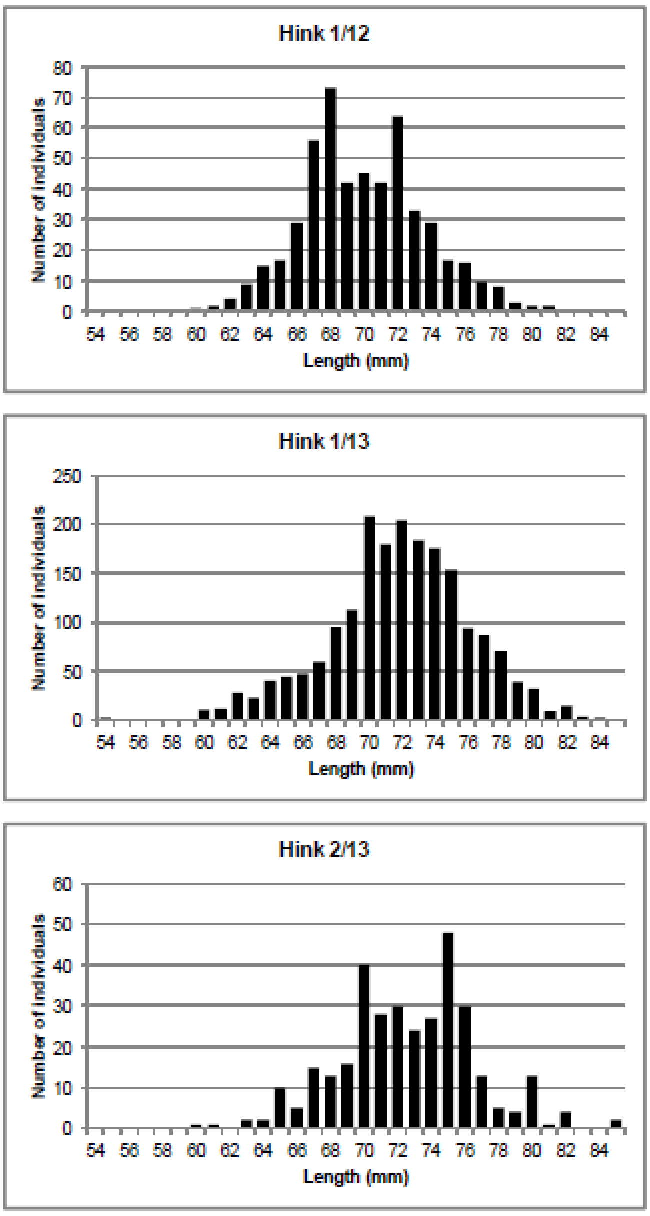

Figure 6 Length distributions for eels caught during February 2012 (Hink 1/12), February 2013 (Hink 1/13) and April 2013 (Hink 2/13).

Figure 1: Glass eel length frequencies from sampling in the Bristol Channel, reproduced from TR274.

Stage 3 - Define the length at which individuals will become impinged rather than entrained at HPC and apportion fish between entrainment and impingement

The entrainment rates presented in Stage 1 represent an estimate of the number of fish which could enter the intake and are of a small enough size to be captured by an ichthyoplankton net of 270µm. The ichthyoplankton surveys may capture individuals of a sufficient length to become impinged upon a 5mm drum screen mesh. No analysis of fish lengths or sizes is presented in TR148 however, to apportion the fish captured by the ichthyoplankton net to whether they would be impinged or entrained. The individuals will therefore, be assigned a length-frequency distribution based on a uniform distribution between the length-at-hatching and the largest length at which they can pass freely through the 5mm screen, as described in Stage 2.

Using the entrainment data presented in Stage 1, and the length-frequency distribution presented in Stage 2, individuals must be apportioned between those which would become impinged upon the 5mm drum and band screens, and those which would pass through and become entrained.

This apportionment is done by identifying the fineness ratios of the species. The fineness ratio is defined for each species as their length divided by their minimum dimension (depth or width). Fineness ratios have been assigned for all species for the Technical Brief: FRR Mortality Rates (EA, 2019a), but given the morphological differences between the larvae, juvenile and adult life stages of some species, the fineness ratios have been checked for their appropriateness for use for larval and small juvenile individuals for the current Technical Brief. A revised set of fineness ratios where considered appropriate, and likely sizes of entrained individuals has been presented below in Table 4 for all species considered by this assessment.

Table 4: Fineness ratios relevant for age-0 juveniles or larval individuals of the fish species under consideration. Fineness ratios provided by Cefas in TR456 Ed2 are presented. These are generated from morphometric equations related to fish length but as these relationships are likely to be based on larger juvenile or adult fish then their application to small juveniles is unclear. Revised fineness ratios for use have therefore been provided with associated references.

Species	Fineness ratio used by Cefas in TR456 Ed2 (based on a 20mm SL fish)	Fineness ratio recommended for larval / juvenile fish	Estimated maximum length of fish (SL, mm) which could pass through 5mm drum and band screen mesh without coming into contact with screen	Length range of individuals which could be entrained through 5mm screen at HPC (SL, mm)	Length range of individuals which could be impinged on 5mm screen at HPC but would have been entrained through 10mm screen at HPB (SL, mm)	Notes
European sprat	Not used	4.75*	24	2.55-24	24-47.5	Fineness ratio calculated incorporates fish from 26mm therefore is likely to be appropriate for larval and very small juvenile individuals.
Whiting	8.75	3.92*	19.6	3.2-19.6	19.6-39.2	
Dover sole	3.21	2.74	13.7	2.50-13.7	13.7-27.4	Fineness ratio based on flatfish morphometric calculates where SL is 84.3% of TL, and body depth is 30.8% of TL. This is used as the screen is a 5mm x 5mm square aperture, so vertical orientation of the individual would not elevate risk of passage through the screen.
Atlantic cod	21.87	3.92*	19.6	3.3-19.6	19.6-39.2	
Herrings (used for Atlantic herring)	Not used	4.75*	24	4-24	24-47.5	Fineness ratio calculated incorporates fish from 26mm therefore is likely to be appropriate for larval and very small juvenile individuals.
European seabass	3.71	3.67*	19	3.61-19	19-36.7	Fineness ratio calculated incorporates fish from 30mm therefore is likely to be appropriate for larval and very small juvenile individuals.
European plaice	1.88	2.74	13.7	6-13.7	13.7-27.4	Fineness ratio based on flatfish morphometric calculates where SL is 84.3% of TL, and body depth is 30.8% of TL. This is used as the screen is a 5mm x 5mm square aperture, so vertical

Species	Fineness ratio used by Cefas in TR456 Ed2 (based on a 20mm SL fish)	Fineness ratio recommended for larval / juvenile fish	Estimated maximum length of fish (SL, mm) which could pass through 5mm drum and band screen mesh without coming into contact with screen	Length range of individuals which could be entrained through 5mm screen at HPC (SL, mm)	Length range of individuals which could be impinged on 5mm screen at HPC but would have been entrained through 10mm screen at HPB (SL, mm)	Notes
						orientation of the individual would not elevate risk of passage through the screen..
Thornback ray	NA					
Blue whiting	5.46	3.92*	19.6	2-19.6	19.6-39.2	
European eel	16 (based on yellow eels)	39**	195	54-86	All individuals will be entrained	There is evidence that glass eels are considerably finer than yellow eels, and the fineness ratio has been adjusted accordingly.
Twaite shad	Not used	4.75*	23.75	NA	40-47.5	
Allis shad	Not used	4.75*	23.75	NA	40-47.5	
Sea lamprey	23.70	18	90	NA	155-180	Fineness ratio for transformers based on unpublished data from the Dee, North Wales
River lamprey	16	18	90	65-90	90-180	Fineness ratio for transformers based on unpublished data from the Dee, North Wales
Atlantic salmon	NA					
Sea trout	NA					
Brown shrimp	Not used	6.88***	34.4	2.3-34.4	34.4-68.8	
Gobies	Not used	5.70*	28.5	3-28.5	28.5-57	Fineness ratio calculated incorporates fish from 20mm therefore is likely to be appropriate for larval and very small juvenile individuals.

Species	Fineness ratio used by Cefas in TR456 Ed2 (based on a 20mm SL fish)	Fineness ratio recommended for larval / juvenile fish	Estimated maximum length of fish (SL, mm) which could pass through 5mm drum and band screen mesh without coming into contact with screen	Length range of individuals which could be entrained through 5mm screen at HPC (SL, mm)	Length range of individuals which could be impinged on 5mm screen at HPC but would have been entrained through 10mm screen at HPB (SL, mm)	Notes
Sandeels	Not used	10.2*	51	4-51	51-102	Although reference is for sandeels >10cm in length, they are elongate whilst larval and juvenile, so similar fineness ratio is considered an appropriate estimate.
European flounder	Not used	2.74	13.7	2.3-13.7	13.7-27.4	Fineness ratio based on flatfish morphometric calculates where SL is 84.3% of TL, and body depth is 30.8% of TL. This is used as the screen is a 5mm x 5mm square aperture, so vertical orientation of the individual would not elevate risk of passage through the screen.
Sand smelt	Not used	5.29*	26.45	6-26.45	26.45-52.9	

*Turnpenny, A. W. H. (1981) An analysis of mesh sizes required for screening fishes at water intakes. Estuaries, 4: 363-368.

Naismith, I. A. and Knights, B. (1988) Migrations of elvers and juvenile European eels, *Anguilla anguilla* L., in the River Thames. *Journal of Fish Biology*, **33 161-175.

*** Sharawy, Z. (2012) Investigations into growth and nutritional condition of Crangon crangon (L.)

Stage 4 – Define entrainment and impingement mortality and EAV

The impingement mortality rates as defined in the Technical Brief: FRR Mortality Rates and the entrainment mortality rates as defined within TR148 (used unchanged, verification of appropriateness not undertaken), are used to calculate the number of fish not surviving impingement and entrainment can be calculated.

The individuals which do not survive impingement and entrainment are then added into the agreed Equivalent Adult Value (EAV) models. This generates an EAV of the fish likely to be entrained at HPC, and those fish which would have been entrained at HPB but are now impinged at HPC due to the change in drum screen mesh size.

An EAV of 1, as used in TR456 Ed2 for European eel, is considered to be too precautionary for glass eels. Conversion of glass eels to escaping silver eels (used as a proxy for equivalent adults) is made in the Eel Management Plan reporting (Defra, 2015). This reporting uses a conversion of 1kg glass eels equating to 59.4kg silver eels and a survival probability from glass eel to spawning escapement of 8.43%, which is proposed to be taken as the EAV factor for the species.

The EAV numbers generated can be added to the EAVs already calculated for impingement losses using the CIMP data.

RESULTS

Stages 1-4 have been progressed for the species listed in Table 5 below, with the total additional EAV numbers provided to add to the EAV numbers of the impinged fish from the assessment using the CIMP data.

Table 5: Assessment of EAV of additional entrained and impinged fish eggs and larvae at HPC not taken into account in TR456 Ed2.

Species	Number of eggs	Egg entrainment mortality (from TR148)	Egg entrainment EAV factor	Egg entrainment EAV number	Number of larvae (total) as estimated in TR148	Number of larvae (entrained)	Number of larvae (impinged)	Larvae entrainment mortality (from TR148 and SPP063)	Larvae impingement mortality (from FRR Mortality Evidence Report)	Larvae entrainment EAV factor	Larvae impingement EAV factor	Larvae entrainment EAV number	Larvae impingement EAV number	Total additional EAV from entrainment and impingement due to 10mm to 5mm screen size mesh change (Egg entrainment EAV number + larvae entrainment EAV number + Larvae impingement EAV number)
European sprat	**0**			**0**	**7,114,303**	**3,557,152**	**3,557,152**	**100.00%**	**100.00%**	**3.50E-02**	**3.87E-01**	**124500**	**1376618**	**1,501,118**
Whiting	Not assessed as no entrainment estimate provided.													
Dover sole	**9,912,120**	**10.00%**	**1.42E-18**	**1E-12**	**2,298,516**	**1,106,693**	**1,191,823**	**100.00%**	**27.20%**	**1.63E-08**	**5.45E-03**	**1.80E-02**	**1767**	**1,767**
Atlantic cod	Not assessed as no entrainment estimate provided.													
Atlantic herring	**0**			**0**	**414,615**	**193,487**	**221,128**	**100.00%**	**100.00%**	**1.38E-03**	**2.22E-01**	**267**	**49090**	**49,357**
European seabass	**47,282,931**	**20.00%**	**1.45E-91**	**1E-84**	**41,981,786**	**20,391,153**	**21,590,633**	**30.00%**	**60.81%**	**1.91E-11**	**4.96E-05**	**1.17E-04**	**651**	**651**
European plaice	**0**			**0**	**3,322,735**	**1,300,201**	**2,022,534**	**100.00%**	**27.20%**	**1.18E-05**	**2.87E-02**	**15**	**15789**	**15,804**
Thornback ray	Not assessed as no entrainment estimate provided.													
Blue whiting	Not assessed as no entrainment estimate provided.													
European eels	**0**			**0**	1,581,697	1,581,696		34.04%		0.0843		45387.91	0	1,581,697
Twaite shad	Not assessed as no entrainment estimate provided.													
Allis shad	Not assessed as no entrainment estimate provided.													
Sea lamprey	Not assessed as no entrainment estimate provided.													
River lamprey	Not assessed as no entrainment estimate provided.													
Atlantic salmon	Not assessed as no entrainment estimate provided.													
Sea trout	Not assessed as no entrainment estimate provided.													
Brown shrimp	Not assessed as no entrainment estimate provided.													
Gobies	**0**			**0**	**10,351,234**	**5,081,515**	**5,269,719**	**100.00%**	**27.20%**	**No EAV calculated**	**No EAV calculated**			**-**
Sandeels	**0**			**0**	**9,075,949**	**4,308,784**	**4,767,165**	**100.00%**	**27.20%**	**No EAV calculated**	**No EAV calculated**			**-**
European flounder	**0**			**0**	**2,711,333**	**1,305,457**	**1,405,876**	**100.00%**	**27.20%**	**No EAV calculated**	**No EAV calculated**			**-**
Sand smelt	Not assessed as no entrainment estimate provided.													

Consideration of uncertainty

No uncertainty estimates are placed around the original entrainment estimates (or entrainment mortalities) as these were accepted through the DCO process and these are not expected to be influenced by the removal of the AFD. The split between fish impinged upon a 5mm mesh screen and those passing through the 5mm mesh screen to become entrained has also not had uncertainty applied. This is because for the majority of species quantitative uncertainty estimates for the fineness ratios used are not available, and data on the length-frequency distribution of the entrained and impinged fish is not available to make a quantitative estimate of uncertainty. Uncertainty around the FRR mortality rates will be used from the Technical Brief: FRR Mortality Rates. Finally, uncertainty around the EAV factor values for entrained and impinged fish have been calculated using the same methods as in the Technical Brief: EAV Methodologies (EA, 2019b), with different final values generated by virtue of the different length-frequency distribution of fish used.

The EAV values for the entrainment and additional impingement of fish larvae are provided in Table 6 below. No uncertainty is placed around the EAV estimates for the entrained eggs given their negligible contribution to the overall EAV numbers, and for those species that have not had uncertainty within their EAV calculated in the Technical Brief: EAV Methodologies.

Table 6: Uncertainty applied to spawner production foregone EAV factor estimates for the entrained and additional impinged portion of fish

Species	Larvae entrainment EAV factor (mean±SD)	Larvae impingement EAV factor
European sprat	3.22E-02±1.36E-03 (normal distribution)	3.69E-01±4.74E-03 (normal distribution)
Dover sole	1.63E-08	5.45E-03
Atlantic herring	8.53E-04±2.52E-04 (normal distribution)	1.98E-01±6.47E-03 (normal distribution)
European seabass	1.91E-11	4.96E-05
European plaice	5.07E-06±3.02E-06 (normal distribution)	2.35E-02±2.01E-03(normal distribution)
European eel	0.0843	-

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