HINKLEY POINT C PERMIT VARIATION

EPR/HP3228XT/V004

Technical Brief: TB018

Review of European Eel population metrics for the Severn Estuary.

National Fisheries Services, Environment Agency.

2020 - Draft-04

INTRODUCTION

As part of the permit variation application (EPR/HP3228XT/V004) we need to compare the predicted losses from the population due to the predicted entrapment and associated mortality from Hinkley Point C's proposed cooling water system. To do this we need to estimate the size of the population the entrapment losses will occur from.

This document sets out the current evidence and data considered and the Environment Agency's proposals within this permit variation assessment.

Life cycle

European eel life history is complex and atypical among aquatic species, being a long-lived semelparous and widely dispersed stock. The shared single stock is panmictic (Palm et al., 2009) and data indicate the spawning area is in the southwestern part of the Sargasso Sea and therefore outside Community Waters (McCleave et al., 1987; Tesch and Wegner, 1990). The newly hatched leptocephalus larvae drift with the ocean currents to the continental shelf of Europe and North Africa where they metamorphose into glass eels and enter continental waters. The growth stage, known as yellow eel, may take place in marine, brackish (transitional), or freshwaters. This stage may last typically from two to 25 years (and could exceed 50 years) prior to metamorphosis to the silver eel stage and maturation. Age-at maturity varies according to temperature (latitude and longitude), ecosystem characteristics, and density-dependent processes. The European eel life cycle is shorter for populations in the southern part of their range compared to the north. Silver eels then migrate to the Sargasso Sea where they spawn and die after spawning, an act not yet witnessed in the wild. (ICES, 2014).

Range

The European eel (Anguilla anguilla) is distributed across the majority of coastal countries in Europe and North Africa, with its southern limit in Mauritania (30°N) and its northern limit situated in the Barents Sea (72°N) and spanning all of the Mediterranean basin (ICES, 2014; Figure A-1). The spawning area in Sargasso Sea is thought to be situated quite narrowly between latitudes 23° and to 29.5°N but on a wider longitudinal range from 48° to 78°W (McCleave et al., 1987; Tesch and Wegner, 1990). At the continental scale, eels have a wide and scattered distribution and are found in virtually all types of water bodies from rivers and lakes to estuaries and coastal waters. Its distribution area is estimated to be at ca. 90 000km^2 (Moriarty and Dekker, 1997; Dekker, 2009).

Status and trends

ICES provides annual stock advice on the European eel throughout its natural range, on behalf of the European Commission. (ICES 2019) describes the status of the global stock as critical, on the basis that the annual recruitment to European waters in 2018 remained low, at 1.9% of the 1960-1979 level in the “North Sea” series and 8.9% in the “Elsewhere Europe” series. ICES advises that “when the precautionary approach is applied for European eel, all anthropogenic impacts (e.g. recreational and commercial fishing on all stages, hydropower, pumping stations, and pollution) that decrease production and escapement of silver eels should be reduced to – or kept as close to – zero as possible.”

The European eel global stock was listed (in 2008 and again in 2014) as Critically Endangered in the IUCN Red List (Jacoby & Gollock, 2014). Regional and national red listings are either Critically Endangered (HELCOM Baltic region, Sweden and Denmark) or Endangered (Finland, northern Africa) (Azeroual, 2010). There is no separate red list assessment for European eel in UK waters.

As part of a CITES Non-Detrimental Finding assessment (Defra, in press), the overall intrinsic vulnerability of the species, as determined using the Worksheet in Mundy-Taylor et al. (2014), has been assessed as ‘Medium to High’. The individual biological factors were graded as 2 ‘Low’ vulnerability, 6 ‘Medium’, 1 ‘High’ and 2 ‘Unknown’. The ‘High’ was for the current stock size being <25% of baseline abundance, and this was given a higher weighting on the overall score.

However, the eel is also assessed at finer regional, national and sub-national scales below the spatial scale of the full stock.

UK Stock Assessments

According to the EU Eel Regulation (EC 1100/2007), the UK developed 14 Eel Management Plans (EMPs), set at the River Basin District (RBD) level, as defined under the Water Framework Directive (WFD: 2000/60/EC), covering England, Wales, Scotland and Northern Ireland.

In the EMPs approved by the European Commission, the UK listed a range of management and conservation measures currently in place or to be enacted.

The main thrust of the Eel Recovery Regulation is aimed at increasing the production and escapement of silver eels against a conservation target; Council Regulation (EC) No 1100/2007 states in Article 2 section 4:

“*The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with a high probability the escapement to sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would exist if no anthropogenic influences had impacted on the stock*”.

Fisheries management is a devolved policy area in the UK and, as such, EMPs were drawn up by the relevant UK authorities within each of the devolved administrations. Assessment methods differ between England and Wales, Scotland and Northern Ireland (see Annexes A to C of Defra, 2018), but every 3 years the UK reports the same stock indicators for each EMP, as follows:

- $B_{current}$: the amount of silver eel biomass that currently escapes to the sea to spawn;
- B_0: the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock;
- B_{best}: the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock;
- $\sum F$: the fishing mortality rate, summed over the age-groups in the stock;
- $\sum H$: the anthropogenic mortality rate for the combined non-fishery factors impacting on eel.
- $\sum A$: the sum of anthropogenic mortalities, i.e. $\sum A = \sum F + \sum H$.

UK escapement biomass and mortality rates cannot be measured directly at the River Basin District scale, so are modelled using a range of input data. The analytical approaches require a number of assumptions about the life history and production of eel and there is natural variation (spatial and temporal) inherent within the input data used in the analyses. Hence, the assessments are described as ‘best available estimates’ and should be treated as such.

Review of Application

Within the application a population estimate is derived from the Severn Eel Management Plan, March 2010. The silver eel output from the Severn RBD is estimated to be about 8.4 kg per hectare. This is derived from 9.5 kg / ha for the reach of river downstream of Worcester and 8.2 kg / ha for the section of river upstream of Worcester including the Avon and Teme catchments, weighted by comparative wetted area of those reaches. Multiplied by the total assumed wetted area, this biomass equates to about 133t of silver eel per year. The applicant uses an assumed wetted area of 15,881 ha (i.e. 133 400 kg / 8.4 kg / ha).

133t is noted to be above the 40% escapement target and so the applicant calculates the target at 15,881 x 6.76kg/ha = 107.36 t. 6.76kg is 40% of the historic production rate of 16.9kg/ha. The application then states this leaves a fishery potential of 26 t (i.e. 133.4 – 107.36) if fishing is allowed to resume. However they do not appear to use this 26t figure as an SSB/fishery comparator, which seems correct – there is no known prospect of any escapement target excess being made available for silver eel fishery exploitation.

In fact under current escapement estimates for the Severn RBD, the 40% escapement target is failing to be met by a large margin – there is no “excess”. In addition, the EU called for additional fishery restrictions on marine/coastal eel in 2018 and the current ICES advice is to reduce anthropogenic impacts on the eel population to as close to zero as possible (ICES 2019).

The applicant then goes on to say: “We consider that the most useful indicator of impact is a comparison between impingement data for eels (although these are not differentiated by life stage) at Hinkley Point power station and estimates of the reported catch of each life stage 2005–2008 in the Severn Estuary RBD. A total of 774 kg of glass eels was declared as caught in the Severn RBD in 2005, 684 kg in 2006 and 1,254 kg in 2007. The declared annual catches of yellow eels in the years 2005–2007 were 4088, 2785 and 892 kg respectively, and 419, 968 and 133 kg of silver eels”. It does not appear to then extend this analysis any further and these figures are not used as SSB/fishery comparators in the application assessment.

For a species which is regarded as critically endangered, forms a feature of the Severn Estuary-specific SAC and Ramsar designations and whose fishery is limited not by stock levels but regulatory controls, it would seem incorrect to base HPC impingement impact assessments upon these fishery returns alone.

The most recent Environment Agency assessment of English eel stock indicators was published in 2018 (ICES 2018a) and is based upon riverine yellow eel survey data from 2014-2016. By way of direct comparison, the modelled mean escapement of silver eel (B_{curr}) from the combined Severn RBD and South West RBD over that period of 87.178t (Table 2)is lower than the 133t for the Severn RBD alone that was used in the application. This represents 1.2% of the baseline escapement target figure (B_{curr}/B_0), whereas the escapement target is 40%. The difference between the 2010 and 2018 escapement estimate and compliance with the management target reflects a combination of modelled reductions in escapement based upon the relevant yellow eel surveys, changes to methodology and to the baseline escapement figure (B_0). These changes are detailed in Defra (2018).

Proposals

The Severn Estuary and its rivers constitute the largest eel fishery in the UK; constituting 95% of all glass eels (juveniles migrating towards freshwater) caught in England and Wales. The River Parrett supports the second most productive elver fishery in England (Langston et al. 2003). However a recent completion of a 30- year study of the estuarine population of yellow eel (Anguilla anguilla) abundance in Bridgwater Bay showed that the population number has collapsed since 1980 at an average decline of 15% per year (Henderson, 2011). The abundance of eel in 2009 is estimated at only 1% of that in 1980 and the exact reasons for the decline are unknown.

The European eel is listed as critically endangered on the IUCN red list for threatened species. In March 2009, the European eel was also added to the Convention on International Trade of Endangered Species (CITES) Appendix II list to control trade. Advice from the International Council for the Exploration of the Sea (ICES) indicates that the stock of the European eel is outside safe biological limits across European waters (ICES, 2006) To enable the recovery of stock, the European Union adopted Council Regulation No. 1100/2007/EC, which requires Member States to develop national management plans, to “permit with high probability the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock”.

The Environment Agency (EA) has worked with Cefas, Defra and Welsh Government to produce 11 Eel Management Plans to cover all of the River Basin Districts (RBDs) in England and Wales (Defra 2010).

Geographically, there are two RBDs of relevance to the potential impacts of the HPC intake on eel. In all likelihood, the Severn RBD (Figure 1) covers by far the greatest number of rivers to which any entrapped eels may be destined, or moving between.

Figure 1 – Severn River Basin District (RBD).

In contrast, the South West RBD (Figure 2) features only a few rivers that are likely to be linked to HPC impacts on eel. In particular, the Parrett catchment (which includes the River Brue, Tone and Kings Sedgemoor Drain) has historically been highly productive and still supports an active elver fishery. It is also the case that the HPC intakes will be situated relatively close to the River Parrett estuary. In recognition of these factors, the relevant data from the River Parrett catchment has been considered as part of this impact assessment, in terms of the estimated annual eel population it supports. The contribution of the other, more distant rivers from the South West RBD has been excluded for the population estimate related to the entrainment impact. This approach is considered to support realistic assessment, as it considers HPC impacts upon a larger stock component than using only the Severn RBD population estimates. For the comparatively small impingement impact, the whole of the South West RBD has needed to be used, as it is not possible to delineate the Parrett catchment from the wider RBD modelling outputs.

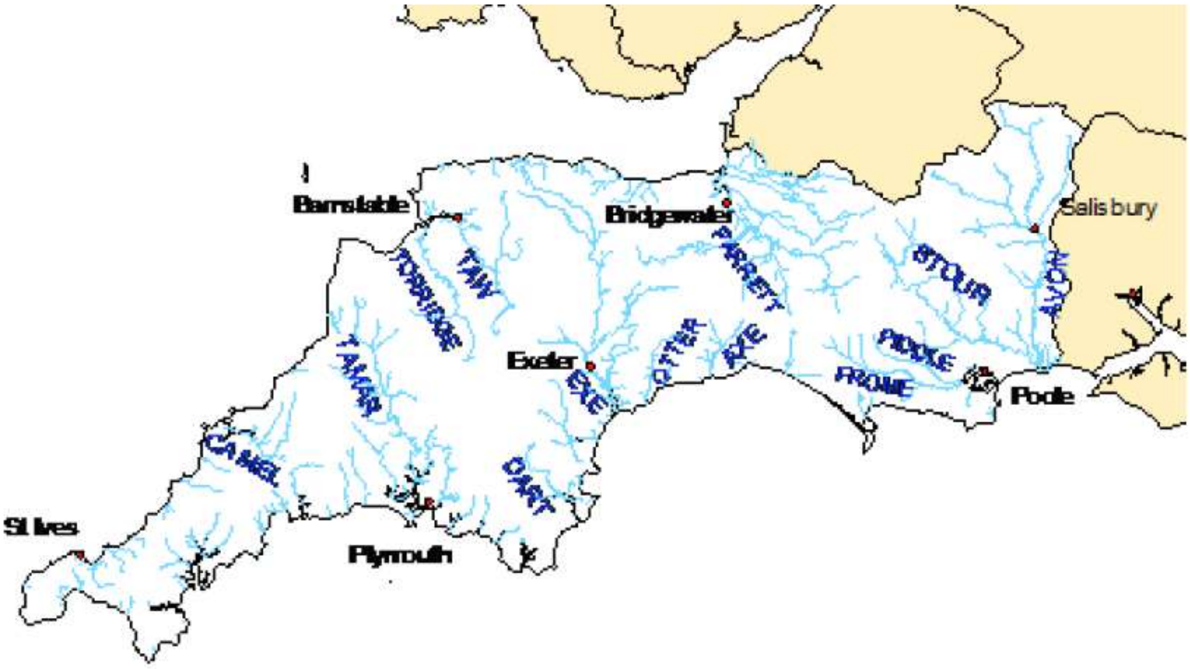

Figure 2 - South West RBD

Using the Defra/Environment Agency Probability Model (Defra 2010), silver eel output from the Severn RBD was estimated to about 133.4t of silver eel per year, as outlined above. This is what was used in the application.   This estimate was derived from 1983/84 yellow eel survey data, and hence there are now more recent data and estimates to be used. These original results were published in the EA's original Severn RBD Eel Management Plan of 2010, stating it as the current estimate on the basis that eel population data from 1983-2007 didn't show major changes in eel density:

> "We conclude from these analyses that, overall, the eel population downstream from Worcester (Zones A to D) has shown little change since the early 1980s, over the time period when average recruitment to Europe has declined substantially. However, there has been a general decline in densities of larger eels in recent years."

Subsequently, the EA developed a new model (SMEPII – Environment Agency 2013) which it now applies to yellow eel survey data for a rolling three year period (starting from 2008-2010) to derive ongoing eel population estimates on the most current freshwater eel survey data. These estimates are reported to Europe and Defra for the purposes of the UK's Eel Management Plan obligations, and have been used by the Environment Agency to assess potential impacts of the HPC permit variation upon eel for the purposes of the Habitats Regulation Assessment.

Impingement assessment

As part of this assessment the EA propose to use the silver eel escapement estimates (based upon the B_{curr} stock indicator) from this newer SMEPII model, from the three year period most closely aligned to the years during which the CIMP data was collected (2009/10). This is represented by the 2008-2010 period which gives a mean 2008-10 modelled annual silver eel escapement biomass for the Severn and South West RBDs of 213.709t per annum (

Table *2*). The whole of the South West RBD has been used (as opposed to model outputs for the Parrett Catchment only for the population estimate relating to the entrainment impact) as it is not possible to delineate the Parrett catchment modelling outputs for the escapement biomass. This figure will be used as the Spawning Stock Biomass to compare the predicted impingement losses from HPC against to produce the proportional population loss predictions. This stock indicator is considered appropriate as a comparator to the impinged fraction of the entrapment impact, as the HPC pressure is applied to the yellow/silver eel life stage that may be close to, or at the point of escapement. The impinged eels will be the survivors of the various mortality pressures applied to this metric in the SMEP II modelling.

A more complex approach was considered, whereby adult eel impingement is related to eel densities in rivers over the time period when the impinged silver eels would have been yellow eels. However, this is complicated due to the large variation in residence time of eels, including differences between sexes. Due to the number of assumptions this would introduce it was deemed inappropriate for this assessment.

Entrainment assessment

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 *1*, overleaf). These figures are slightly different to those presented by the applicant, likely to be due to the Environment Agency approach of pooling 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.

Table 1 Glass eel densities from surveys at proposed HPC intake location as determined from raw trawl data in TR S-211 and TR274.

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

The process of converting glass eel densities to an estimate of entrainment as silver eel equivalents is described in detail in our Feature Impact Assessment Template for eel.

This more recent, and localised data on glass eel density means a robust assessment can be devised to predict the mortality of glass eels due to entrainment at HPC.

A number of approaches to deriving a suitable population indicator to apply the entrainment impact to, were discussed with Environment Agency eel specialists. Briefly, these are outlined below:

1) Use of the combined B_{curr} SMEPII outputs (current estimated annual silver eel escapement in the presence of anthropgenic mortality) for the Severn and SW RBDs (not possible to delineate the Parrett catchment from the wider RBD).

2) Use of post-fishery and post-barrier pressure SMEPII outputs (based directly upon the yellow eel survey data).

3) Use of pre-fishery and pre-barrier pressure SMEPII outputs (based upon the yellow eel survey data, but with annual glass eel fishery reported catches added back in, plus a barrier coefficiant to increase the population estimate.

4) Use of glass eel run sizes based upon the recent Non Detrimental Finding (Defra 2020) for future trade in European eels from the United Kingdom (UK) following its exit from the European Union (EU).

After detailed assessment and discussion within the group, it was concluded that each method was potentially valid, but that they all had areas of uncertainty and data deficiency to varying degrees. This is not entirely unexpected given the absence of critical information such as a robust annual glass eel recruitment, level of fishery exploitation or degree to which density-dependant mortality affects recruitment in the Severn SAC, or any catchment which could used as an anologue.

Method 3) was selected as being the most relevant for the purposes of this specific assessment. In further detail, this method takes the SMEP II-modelled estimate of silver eel escapement (expressed as kg/yr) for the Severn RBD, plus the River Parrett, averaged over the period of 2005-2016 (to account for large varience in the outputs over the period). These outputs are derived from the EA's freshwater riverine surveys and therefore provide population estimates derived from eel life stages that have already experienced mortality pressures - primarily from the glass eel fishery, barriers to migration and density-dependant mortality.

In order to reconstruct a population estimate of glass eels (as silver eel equivalents) at the lifestage and geographical location that the HPC entrainment impact would occur, the reported glass eel fishery catches from 2005-16 (as silver eel equivalents) for the Severn and South West RBDs (the Parrett-specific glass eel catches are not available but are considered to make up a very large % of the total reported SW RBD glass eel catches) are added back onto the yellow eel-derived silver eel estimates. The 2005-16 period was selected as it included relatively large catches from the high recruitment year of 2014, and some particularly low catches from 2005-2009 but excluded the historically much higher returns preceeding this period.

Similarly, the Barrier Coefficiant used in the SMEP modelling to reflect barrier mortality for the Severn and South West RBDs was applied to the population estimate. Being <1, this has the effect of removing the barrier pressure and increasing the population estimate further.

The result of these two steps is a potential pre-fishery and pre-barrier estimate of glass eel biomass supporting the Severn RBD and the River Parrett, expressed as silver eel equivalents. This is the selcted population metric to compare HPC entrainment losses againt.

It was agreed not to extend the adjstments to try and account for density-dependant mortality, given that there is no scientific certainty that it applies in the Severn SAC, or that if it does, to what degree. The most relevant assessment in the literature comes from Lough Neagh (Aprahamian et al., 2018) where the environment, fishery and eel population dynamics are very different from the Severn SAC.

It should be noted that the other tested methods 1,2 and 4 all produced higher expected % annual entrainment impacts on eel than method 3. It could be suggested that the need for a precautionary approach within and HRA might drive the selection of one of these methods in preference for one which suggests a lower impact. However these alternatives also introduced greater levels of uncertainty and reliance on subjective rather than evidence-based views when considered specifically for this current assessment. It is quite possible that these metrics, or others like them would be appropriate for other impact assessment on eel for other purposes.

Within this assessment, we intend to use the outputs of method 3 described above as the silver eel equivalent population estimate to compare the entrainment impacts against. These are 243,436kg for the Severn RBD and 87,812kg for the River Parrett; therefore 331,248kg combined. (***Table 3***).

Uncertainty assessment

To consider the potential inter-annual variability within the modelled output being proposed as the best estimate for the impingement assessments for the combined Severn and South West RBDs (2008-10), the Environment Agency is proposing to use the upper and lower population estimates currently reported from SMEPII within this reporting period (

Table *2*).For the reporting period 2009-2010, the 2009 estimate represents the lower range at 213,245 and the 2010 period represents the upper range at 214,173.

For the entrainment estimate, the range of SMEPII-modelled outputs from 2005-2016 for the potential pre-fishery and pre-barrier estimate of glass eel biomass supporting the Severn RBD and the River Parrett, expressed as silver eel equivalents (range 125,381 - 839,218 kg)) will be used in the uncertainty analysis. In addition, the range of 2005-16 reported glass eel catch (as kg silver eel equivalents) for the Severn RBD (range 4,562 - 363,878) and River Parrett (range 11,553 - 333,282) will be used.

Throughout this assessment it must be acknowledged that the SMEPII model itself has a degree of uncertainty around the estimates it generates for each year. It is after all based on sample data and various assumptions to define the input parameters. However as yet there is no measure of this within the model and therefore specific model uncertainty is not described in the outputs.

Table 2 SMEPII modelled annual Silver Eel escapement (t) for the Severn and South West RBDs.

Year	B_{curr} (kg silver eel/RBD/yr) as reported		B_{curr} combined Severn and Sourth West RBDs (kg/yr)		Source
	Severn	South West			
2009	151,486	61,759	**213,245**	**213,709**	Based on 2015 EMP
2010	152,460	61,713	**214,173**		
2011	82,534	28,545	111,079	108,760	Based on 2015 EMP
2012	83,264	25,906	109,170		
2013	83,264	22,767	106,031		
2014	81,519	8,289	**89,808**	**87,178**	Based on 2018 EMP
2015	81,252	1,340	**82,592**		
2016	81,252	7,881	89,133		

Table 3 HPC entrainment impact on pre-fishery & barrier escapement potential (SE equivalents).

	Severn RBD	R. Parrett	
SE Escapement SMEP output kg/ha (SE equiv.) (2005-16 mean)	1.18	0.34	kg/ha
Wetted area (FW & Est)	75,071	451	ha
GE Fishery (SE equiv.) (2005-16 Mean)	- 88,237	- 87,611	kg
Barrier Impact Coefficient	0.57	0.76	
Pre-fishery & barrier escapement potential. (SE equiv.)	243,436	87,812	kg

For clarity, the calculations behind Table 3 are as follow (Severn RBD used as worked example):

Mean 2005-16 SMEP output (kg/ha silver eel equivalents) = 1.18

Wetted area = 75,071 ha

Estimated mean annual SE equivalent output = 1.18 * 75,071 = 88,583.78kg

To reconstruct the pre-barrier impact SE equivalent: 88,583.78 / barrier coefficient of 0.570775568470754 = 155,198.97kg

To reconstruct the potential pre-fishery impact SE equivalent: 155,198.97 + mean 2005-16 glass eel catches (as SE equivalents) of 88,237.22 = 243,436.19kg SE equivalents.

Table 4 Conclusion results.

Source	Used in Applicant's assessment	Used in Environment Agency's assessment	
		Predicted	Uncertainty Range
Modelled silver eel escapement for Severn RBD from 2010 EMP (t)	133	N/A	N/A
Modelled mean pre-fishery & barrier escapement potential (SE equivalents)used for entrainment assessment (t p.a.)	N/A	331.248	125.381 – 839.218
Modelled mean silver eel escapement biomass (2008-2010) used for impingement assessment (t p.a.)	N/A	213.709	213.245 – 214.173

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