HINKLEY POINT C PERMIT VARIATION

EPR/HP3228XT/V004

Technical Brief: TB020

Summary Technical Brief: Summary of Quantitative Impact Assessment Results.

National Permitting Service, Environment Agency.

2020 (DRAFT-06)

EXECUTIVE SUMMARY

In 2013 the Environment Agency granted an Environmental Permit to NNB Generation Company (HPC) Limited (NNBGenCo) to operate certain water discharge activities at the proposed Hinkley Point C nuclear power station (HPC).

In 2019 NNBGenCo (the applicant) submitted an application with supporting documents to vary the existing permit to amend or remove conditions relating to the design and operation of the Acoustic Fish Deterrent system (AFD) originally proposed for the cooling water system.

We have reviewed the application and adopted the basis of the assessment model used to predict the amount of fish that will enter and not survive their journey through the cooling water system, and subsequently be lost from the population.

However, we have adjusted several of the input parameters to this model, to meet the requirements of the assessments we must complete as part of the permit variation determination. We've called our adjusted model the '**Quantitative Impact Assessment Model**'.

We are satisfied that the adjustments are reasonable and proportionate considering the evidence and data currently available. To ensure this we have utilised specialists within the Environment Agency as well as appointing a Marine Contractor, APEM LTD. We have also consulted Statutory Nature Conservation Bodies (Natural England & Natural Resources Wales) and the Marine Management Organisation (MMO), taking on board their advice and guidance.

This report concludes a suite of Technical Briefs by providing a summary of the results from our Quantitative Impact Assessment Model. These are expressed as an **annual proportionate loss from the relevant population for each species** assessed in detail. It also makes a comparison between these results, those considered during the original permit application, and those provided in the permit variation application to amend or remove conditions relating to the design and operation of the AFD.

Due to our adjusted input parameters, our predicted annual proportional losses for all the species assessed in detail are higher than those presented in the application. The results range from 0.0001% for Blue Whiting to 22% for Atlantic Cod.

The significance of these results will be considered further within the assessments required as part of the determination under the Environmental Permitting Regulations (2016). These assessments include the Habitats Regulation Assessment (HRA) and Water Framework Directive (WFD) assessment.

INTRODUCTION

In 2013 the Environment Agency (we) granted Environmental Permit EPR/HP3228XT, permitting NNB Generation Company (HPC) Limited (NNBGenCo) to operate certain water discharge activities (WDAs) at the proposed Hinkley Point C nuclear power station (HPC) near Bridgwater.

The permit regulates discharges of trade effluent, including cooling water back into the Bristol Channel. The initial design required the company to abstract and discharge this cooling water using three mitigation measures, which would work together to reduce the environmental impact of this activity. The mitigation measures included in the original permit were a Low Velocity Side Entry intake head (LVSE), a Fish Recovery & Return system (FRR) and an Acoustic Fish Deterrent system (AFD).

In 2019 NNBGenCo (the applicant) applied to vary the existing permit to amend or remove conditions relating to the design and operation of the AFD and has submitted a number of reports alongside its application. We need to consider all of these fully and independently before we can make any decision on whether the applicant's proposals are acceptable or not.

As part of the review, analysis, and determination of this application, we will complete and document the following assessments *(List A)*:

- A Habitats Regulations assessment (HRA), under The Conservation of Habitats and Species Regulations 2017.
- An Appendix 4 assessment under the Countryside and Rights of Way Act 2000 (CRoW).
- A Water Framework Directive assessment, under the Water Environment (Water Framework Directive) Regulations 2017.
- An Eel Regulations assessment, under the Eels (England & Wales) Regulations 2009.
- A Best Available Techniques (BAT) assessment, under the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR).

In order to carry out these assessments (*List A*) and make a decision on whether the applicants' proposals, as presented in the permit variation application and supporting documentation, is environmentally acceptable or not, we must establish the risk and potential impact on the environment from operating the HPC cooling water system without an AFD system.

A key part of establishing these potential impacts, is predicting the amount of fish that will enter the cooling water system and not be returned to the environment alive, and hence be lost from the population.

The approach we took to review the application and supporting documentation, and assessing the numerical data and evidence, is summarised in an overarching Technical Brief (TB000). A series of accompanying technical documents (see *Table 1*) describes details of the approach. We used the resulting Quantitative Impact Assessment Model to predict the amount of fish that would be lost from the population, due to operating the cooling water system at HPC without an AFD. The model process is summarised in *Figure 1*.

This report provides the results of this Quantitative Impact Assessment Model.

Each of the assessments listed above (*List A*) will consider these values (together with any further evidence) qualitatively against the requirements of each of the assessments.

Our role as a regulator

We have a duty to promote the conservation of wildlife and habitats dependent on the aquatic environment. As an environmental regulator it is our duty to regulate activities in controlled waters – including coastal waters out to 3 miles (for control of land based discharges, and pollution incidents). We permit such activities in coastal and estuarine waters under the Environment Permitting Regulations, Radioactive Substances Act, Salmon and Freshwater Fisheries Act and the Water Resources Act. We need to ensure our assessments are compliant with the Conservation of Habitats and Species Regulations 2017, the Countryside and Rights of Way Act 2000, the Water Environment (Water Framework Directive) Regulations 2017, the Eels (England & Wales) Regulations 2009 and OSPAR convention. We also have statutory responsibilities for the management of migratory fish to 6 nautical miles and a duty to maintain, improve and develop fisheries in those waters.

The precautionary principle

Where a plan or project may impact designated sites a Habitats Regulations Assessment (HRA) including an Appropriate Assessment (AA) is required to determine if a plan or project may affect the protected features of a habitats site before deciding whether to undertake, permit or authorise it. The competent authority may agree to the plan or project only after having ruled out adverse effects on the integrity of the habitats site.

In our regulatory capacity, we are obligated to conform to our legal duties regarding the precautionary principle. Defra’s core guidance for developers, regulators & land/marine managers (Defra, 2012) states: “The Government expects competent authorities and licensing bodies to exercise their duties under habitats legislation to help deliver its biodiversity policy by protecting European sites and protected species. They should proceed in accordance with the precautionary approach required by the Directives and, if there is doubt about the impacts of proposed activities, precautionary decisions should be taken to protect relevant sites and species. The absence of information is not a basis to assume no negative effect.”

The legislative framework for this requirement is described in Article 6.4 of the Habitats Directive, section 1.2.1 (European Commission, 2007). The Directive states that, "The preliminary assessment of the impacts of a plan or project on the site, provided for in Article 6(3), enables the competent national authorities to arrive at conclusions regarding the consequences of the initiative envisaged in relation to the integrity of the site concerned. If these conclusions are positive, in the sense that no reasonable scientific doubt remains as to the absence of effects in the site, the competent authorities can give their consent on the plan or project. In case of doubt, or negative conclusions, the precautionary and preventive principles should be applied and procedures under art. 6(4) followed. Furthermore, taking into account the precautionary principle and applying a preventive approach might also lead to the decision not to proceed with the plan or project."

The Defra (2012) guidance goes on to state that, "It is for the competent authority (taking due account of expert advice from the SNCB [Statutory Nature Conservation Bodies]) to decide when there is, and is not, any reasonable scientific doubt on which to decide whether AEoI [Adverse Effect on Integrity] can be ruled out. The authority should proceed on a precautionary basis, and not grant consent for a plan or project if there is doubt over whether AEoI may result."

Table 1 - Suite of technical documents produced during the permit determination, documenting our review of the application and approach taken in developing our Quantitative Impact Assessment Model.

Reference	Title	Summary	Contributing Teams
TB000	Overarching Technical Brief: Description of Quantitative Impact Assessment Process.	Describes the overarching approach we took to review the application and assessing the numerical data and evidence. It summarise the Quantitative Impact Assessment Model.	National Permitting Service, Environment Agency.
TB001	Technical Brief: Vertical Audit and Raw Data Quality Assurance summary report. Accompanying documents: TB001 - Corrected HPB impingement and uncertainty – Excel TB001 - Corrected HPB impingement with shifted cohorts - Excel	Description of our findings from taking the raw data through the impingement assessment, as described by the application documents, identifying any errors.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency.
TB002	Technical Brief: Spawning and nursery periods of marine fish species.	Proposes amended date ranges to ensure that the estimates of impingement reflect the cohorts as spawned in 2009/10, and so can be appropriately compared with the 2009/10 spawning stock biomass (SSB) data.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. Marine Contractor, APEM LTD.
TB003	Technical Brief: The relationship between number of fish impinged and abstraction volume for Power Stations cooling water intakes.	Review of currently available evidence on the association between volume abstracted and numbers impinged.	Operations Catchment Services, Environment Agency. The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency.

TB004	Technical Brief: Accounting for entrainment losses and difference in drum screen size.	Method description to take account of the difference between HPB's screens and HPC's drum & band screens, inclusion of the resulting additional impingement as well as inclusion of the resulting entrainment.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. National Fisheries Services, Environment Agency. Marine Contractor, APEM LTD.
TB005	Technical Brief: Examination of evidence of an ebb tide sampling bias at HPB.	Review of current evidence and analysis of Routine Impingement Monitoring Programme (RIMP) & Comprehensive Impingement Monitoring Programme (CIMP) data.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. Operations Catchment Services, Environment Agency. National Fisheries Services, Environment Agency. NNB HRA Team, Environment Agency.
TB006	Technical Brief: Low Velocity Side Entry Intake Design; effect of intake intercept area. Accompanying document: TB006 - Supporting Calculations - Excel	Review of the scaling factor applied to take account of the intake area difference between HPB & HPC	Operations Catchment Services, Environment Agency.
TB007	Technical Brief: Low Velocity Side Entry Intake Design; effect of intake velocity cap. Accompanying document: TB007 - Supporting Calculations - Excel	Analysis of the velocity cap correction factor applied for pelagic species.	Operations Catchment Services, Environment Agency.
TB008	Technical Brief: Fish Recovery and Return System Mortality Rates. Accompanying document: TB008 - Supporting Calculations - Excel	Review of current evidence and method description on FRR mortality rates proposed for HPC.	Operations Catchment Services, Environment Agency. Marine Contractor, APEM LTD.

TB009	Technical Brief: Biomass Weight and Mortality Report. Accompanying document: Supporting Calculations - Excel	Review of biomass calculation for HPB and predicted estimates for HPC.	Operations Catchment Services, Environment Agency.
TB010	Technical Brief: Converting impingement and entrainment numbers to Equivalent Adult Values and Spawning Production Foregone. Accompanying document: TB010 - Supporting Calculations - Excel	Analysis of converting impingement and entrainment numbers to EAVs and Spawner Production Foregone.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. National Fisheries Services, Environment Agency. NNB HRA Team, Environment Agency. Marine Contractor, APEM LTD.
TB011	Technical Brief: Scale of assessment areas for marine fishes and assessment method comparing Sprat losses with Spawning Stock Biomass.	Reviews of currently available literature and data on more localised populations and methodology to define appropriate estuarine community population estimates.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. NNB HRA Team, Environment Agency. Marine Contractor, APEM LTD.
TB012	Technical Brief: Predicting adult sea trout populations in the Severn Estuary.	Reviews of currently available literature and data and methodology to define appropriate populations estimates.	National Fisheries Service, Environment Agency. Marine Contractor, APEM LTD.
TB013	Technical Brief: HPC Entrapment Predictions – Uncertainty Analysis Report.	Method description and findings from the Monte Carlo analysis model.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. National Fisheries Services, Environment Agency. NNB HRA Team, Environment Agency. Operations Catchment Services, Environment Agency. Marine Contractor, APEM LTD.

TB014	Technical Brief: Safe fish density in drum and band screen fish buckets.	Reviews specific points presented in the report TR493: "The effect of not fitting an AFD system at HPC on the operation of the HPC FRR systems".	Operations Catchment Services, Environment Agency. The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. National Fisheries Services, Environment Agency.
TB015	Technical Brief: Review of adult run size estimates for river lamprey and sea lamprey in the Severn Estuary, River Wye and River Usk.	Reviews currently available literature and data and methodology to define appropriate populations estimates.	Regulation and Compliance, NNB HRA Team, National Biodiversity, Environment Agency.
TB016	Technical Brief: Review of adult run size estimates for Twaite Shad and Allis Shad in the Severn Estuary, River Wye and River Usk.	Reviews currently available literature and data and methodology to define appropriate populations estimates.	National Fisheries Service, Environment Agency. Marine Contractor, APEM LTD.
TB017	Technical Brief: Review of adult run size estimates for Atlantic Salmon in the Severn Estuary, River Wye and River Usk	Reviews currently available literature and data and methodology to define appropriate populations estimates.	National Fisheries Services, Environment Agency. NNB HRA Team, Environment Agency.
TB018	Technical Brief: Review of European (silver) Eel biomass escapement biomass for the Severn Estuary.	Reviews currently available literature and data and methodology to define appropriate populations estimates.	National Fisheries Services, Environment Agency.
TB019	Technical Brief: Statistical Analysis of Routine Impingement Monitoring Programme Data	Considers the use of the RIMP dataset as a predictor of future impacts of the proposed HPC power station on the Severn Estuary and Bristol Channel fish assemblage of the Severn SAC and as a detector of the impacts from HPB during its operation.	The Estuarine and Coastal Monitoring and Assessment Service, Environment Agency. Marine Contractor, APEM LTD. NNB HRA Team, Environment Agency.
TB020 (This report)	Summary Technical Brief: Summary of Quantitative Impact Assessment Results.	Summarises the results of the Quantitative Impact Assessment Model.	National Permitting Service, Environment Agency.

The Quantitative Impact Assessment Model

To support their variation application, the applicant submitted a report (TR456) which aims to predict the effects of impingement through the cooling water system proposed at HPC without an AFD fitted. Within this report an assessment approach is described in section 5, named The Impingement Assessment Process.

We took the basis of this assessment model and reviewed the evidence, data, and justifications presented in the application for each step of the process. We also considered detail supplied during the original permit application and other sources of available evidence and data.

We have adopted this model but made various adjustments to ensure our assessment uses the most up to date evidence and data, and to ensure it meets the requirements of the assessments listed above (*List A*). A key addition was the inclusion of entrainment losses. This ensured our assessment was conducted on the full potential impacts from operating the cooling water system and not solely on impingement (i.e. entrapment predictions, where entrapment = impingement + entrainment).

The resulting methodology is summarised in *Figure 1* and has been termed our Quantitative Impact Assessment Model.

The key aim of this Quantitative Impact Assessment Model is to use the numbers of fish impinged at Hinkley Point B (HPB) to predict the amount HPC will impinge, and using survey data to predict the number of fish HPC will entrain. The HPB information is from two sources. The long-term (37 years) Routine Impingement Monitoring Programme (RIMP) data set and the more intensive (2009/2010) Comprehensive Impingement Monitoring Programme (CIMP) data set. The local survey data included beam trawls, fishing surveys and ichthyoplankton surveys.

A key assumption in using the HPB information is that the HPC will entrain similar numbers of fish to HPB by volume of cooling water abstracted. This is actually unknown where there have been no site specific HPC surveys conducted. For some key species – most notably the migratory species such as the Shads, Lampreys, Salmon and Sea Trout there are ecological reasons why using the HPB intake may under or overestimate the impacts at HPC.

The first step in our analysis is to estimate the number of fish, larvae and eggs expected to enter the HPB cooling water system over a certain period (12 months when using the CIMP data but averaged over longer periods when using the RIMP data). Then scale this figure up to estimate the total number of fish, larvae and eggs that would be expected to enter the HPC cooling water system over that same period, solely based on relative volumes abstracted. The HPC impingement figures are then adjusted for two factors that are based on the difference in the intake head design between HPB and HPC. The LVSE factor corrects for the effect of the Low Velocity Side Entry intake heads. The pelagic cap factor corrects for the lack of vertical component to flows entering the LVSE which reduces the likelihood of near-surface swimming fish being drawn down to the intake head. Next, the amount of the impinged or entrained individuals that would not be expected to survive their journey through the system is predicted. This is done separately for biota impinged and those entrained as the survival rates are different for these two routes.

HPB survey data shows that the majority of impinged or entrained individuals will be juveniles and earlier life stages. Mortality of larval and juvenile fish will not have the same effect on a population as removing the same number of adults would, due to the fact that many of the larvae and juveniles would never have survived to contribute to the spawning population. In order to compare mortality of fish caused by the power station to be compared with population measures of adults the impingement and entrainment values are converted into an equivalent number of adults that these individuals would have produced had they not been removed from the population by HPC, by use of an Equivalent Adult Value factor (EAV factor) for each species.

The numbers of impinged and entrained can then be combined to give a total number of equivalent adults expected to be lost per annum, through entrapment at HPC. For certain species this is converted to a weight in tonnes to allow comparison to population measures such as Spawning Stock Biomass (SSB) or fishery landings data (where SSB is the combined weight of all individuals in a fish stock that are capable of reproducing).

These entrapment losses, expressed as numbers or weights of equivalent adults, are then compared with the population estimate for each species. This gives the percentage of that population, as equivalent adults, we would expect to be lost per year through the operation of HPC. As this is a proportional loss it can be assigned to any given year the power station is operating, under the assumption that the annual proportional loss remains the same as absolute population number increases or decreases.

This process can be represented as the following equation:

Equation 1:

$$Annual\ proportional\ loss = \frac{\left(\left(N_{imp} \cdot F \cdot A \cdot V \cdot M_{imp} \cdot EAV_{imp}\right) + \left(N_{add} \cdot M_{add} \cdot EAV_{add}\right) + \left(N_{ent} \cdot M_{ent} \cdot EAV_{ent}\right)\right) \cdot W}{P}$$

Where:

- N_{imp} *Number of biota impinged calculated from the CIMP or RIMP data*
- N_{add} *Number of additionally impinged biota due to the 10mm to 5mm screen size change*
- N_{ent} *Number of entrained biota*
- F *Scaling factor between HPB and HPC impingement*
- A *Scaling factor for intake tidal intercept area between HPB and HPC*
- V *Scaling factor for intake velocity cap effect between HPB and HPC*
- M_{imp} *Mortality of the impinged fish calculated from the CIMP or RIMP data*
- EAV_{imp} *EAV of the impinged fish calculated from the CIMP or RIMP data*
- M_{add} *Mortality of the additionally impinged biota due to the 10mm to 5mm screen size change*
- EAV_{add} *EAV of the additionally impinged biota due to the 10mm to 5mm screen size change*
- M_{ent} *Mortality of the entrained biota*
- EAV_{ent} *EAV of the entrained biota*
- W *Mean weight of fish within the spawning stock*
- P *Total weight or number of fish within the spawning stock (or captured within the fishery)*

If P is quantified as a number of fish, rather than a weight, then W is omitted from the equation.

Figure 1 - Summary of our Quantitative Assessment Model process

1. Raise HPB impingement data up to full operation

Outcome: Predicted total impingement at HPB over full data set

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2. Select data range to reflect the cohorts as spawned in 2009/10.

Outcome: Predicted total annual impingement at HPB

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3. Scale HPB annual impingement estimates up to HPC abstraction volume.
Factor we applied: 3.91
Uncertainty range we applied: None

Outcome: Predicted annual impingement at HPC's abstraction volume

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4. Apply intake design factors:

A. Intake Intercept Area factor; to take account of the difference between the areas of intake face presented to the incoming water & biota from HPB to HPC's intake heads.
Factor we applied: 1.394
Uncertainty range we applied: 1.24 – 1.591

B. Intake Velocity Cap Factor; to take account of the fact that the intake will be vertically capped and there for only abstract water & biota horizontally. This factor is only applied to pelagic species.
Factor we applied: 0.23
Uncertainty range we applied: 0.18 – 0.28

Outcome: Predicted annual impingement taking account of HPC's intake design

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5. Apply the mortality estimated through the FRR system.
We applied a mortality rate to each species based on current available data/studies.

Outcome: Predicted annual impingement mortality

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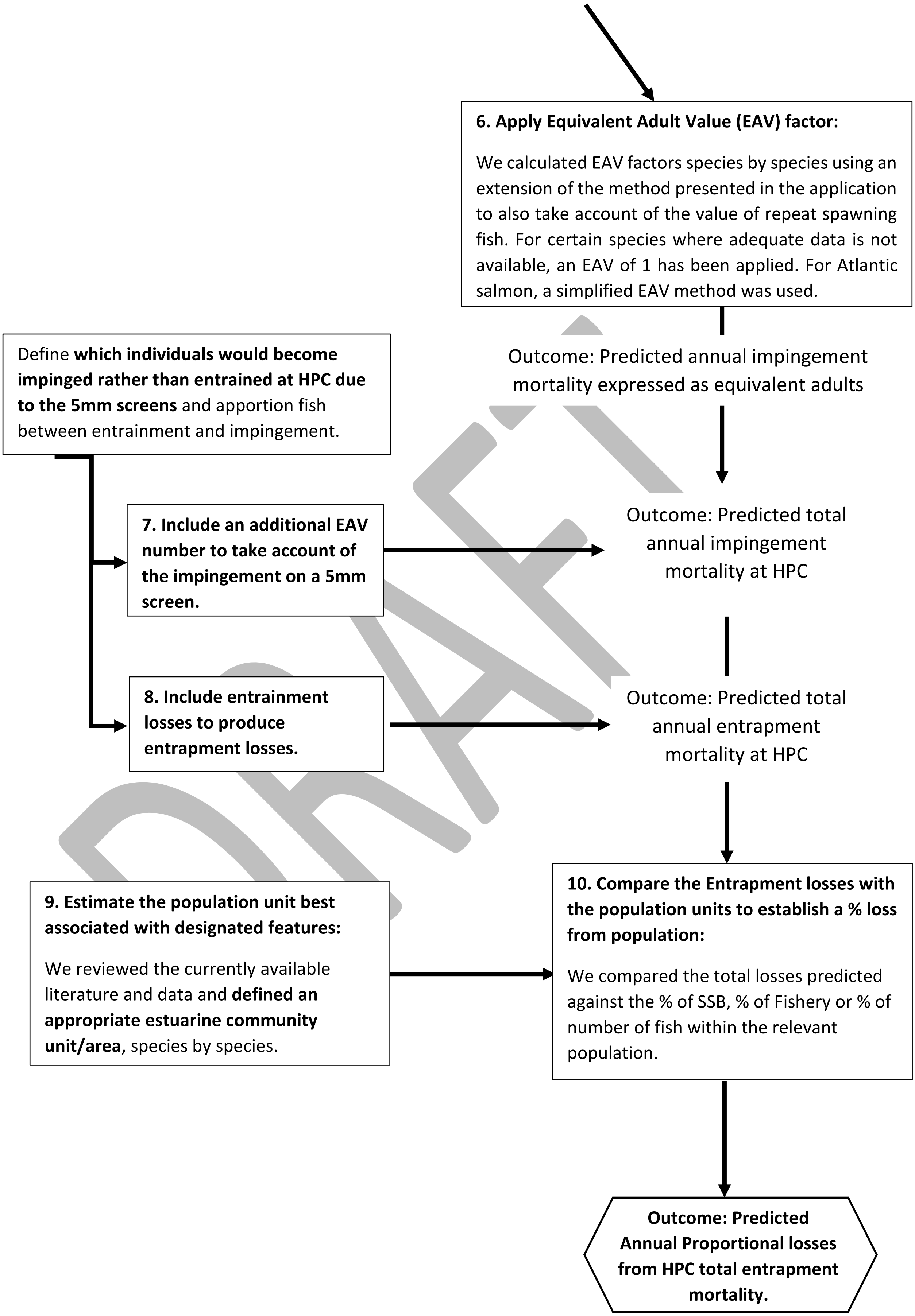
6. Apply Equivalent Adult Value (EAV) factor:
We calculated EAV factors species by species using an extension of the method presented in the application to also take account of the value of repeat spawning fish. For certain species where adequate data is not available, an EAV of 1 has been applied. For Atlantic salmon, a simplified EAV method was used.
Outcome: Predicted annual impingement mortality expressed as equivalent adults
Define which individuals would become impinged rather than entrained at HPC due to the 5mm screens and apportion fish between entrainment and impingement.
7. Include an additional EAV number to take account of the impingement on a 5mm screen.
Outcome: Predicted total annual impingement mortality at HPC
8. Include entrainment losses to produce entrapment losses.
Outcome: Predicted total annual entrapment mortality at HPC
9. Estimate the population unit best associated with designated features:
We reviewed the currently available literature and data and defined an appropriate estuarine community unit/area, species by species.
10. Compare the Entrapment losses with the population units to establish a % loss from population:
We compared the total losses predicted against the % of SSB, % of Fishery or % of number of fish within the relevant population.
Outcome: Predicted Annual Proportional losses from HPC total entrapment mortality.

Predictions and Uncertainty Analysis

As with any assessment model there is uncertainty in estimating such predictions as well as natural variability within each of the parameters. So an analysis of the level of uncertainty at each stage of the assessment has also been carried out. This analysis gives a range of potential losses that could be seen in any particular year. The assessments listed (*List A*) above consider this range of results.

To do this, while reviewing each of the steps in the model above, we considered the reasonable degree of uncertainty around our predictions. So within each step of the assessment process, we not only established the most likely input parameter for each part of the impact model (known as our predicted value), but also a range of input parameters to acknowledge the uncertainty around the predicted values (known as the uncertainty range).

Our predicted input parameters were then used in the Quantitative Impact Assessment Model as outlined above (*Figure 1*) to produce our predicted impact value. The uncertainty ranges for each of these input parameters were then used in a Monte Carlo simulation to produce a probability distribution of the range of potential impact values that may occur in any given year, over the expected lifetime of the power station within reason.

From these probability distributions, a mean uncertainty prediction can be derived, and estimates of annual proportional losses can be made with associated quantitative confidence levels (e.g. we can be X% confident that the annual proportional loss will not exceed Y% in any given year).

For any input parameter, the value deemed to be most likely and used in the calculation of the predicted result, does not necessarily sit in the centre of the possible range of values for that parameter. For this reason, the mean uncertainty prediction does not always correspond with the predicted result. In such cases, the predicted result remains the entrapment mortality that is thought to most likely to occur.

Our predicted values and uncertainty analysis provide objective and robust estimates of impacts but there will always be residual uncertainty due to the highly variable nature of fish numbers and the complex environmental factors underlying that variability. It is important to note that uncertainty analysis examines the variability around our predictions for each parameter, based upon the range of values reported in the literature or expert judgement. However, there are many ‘residual unknowns’ associated with HPC which lie outside the scope of the uncertainty analysis. The assessment model is based on assumptions and if any of those assumptions do not hold true, then the actual impact may differ from the prediction, and may even be outside the range of possible values returned by the uncertainty analysis.

For example, we can place a range around our predictions of HPC impingement numbers based on the variation within the HPB impingement data. But, if the composition of the fish community is fundamentally different at the HPC intake, then this will result in impingement numbers being different to our prediction – the assumption that both intakes will sample from the same community is outside the scope of the uncertainty analysis.

Similarly, we have considered uncertainty around the conversion of fish numbers to equivalent adult values based on the possible range of parameters used in the conversion calculation, such as the proportion of mature fish in each age group. This does not include variation outside the scope of the conversion process, for example, how survival may be higher in lower density populations due to lack of competition for food.

This uncertainty analysis process is outlined in more detail in the Technical Brief: HPC Entrapment Predictions – Uncertainty Analysis Report (TB013).

The final input parameters of our predicted values and uncertainty ranges are included in the ‘Conclusion Results’ sections of each of these Technical Briefs (*Table 1*). They have also been compiled together in the Excel spreadsheet: Quantitative Impact Assessment Input Parameters (*Appendix A*).

Results

The results of the Quantitative Impact Assessment Model for the operation of the cooling water system at HPC with only an LSVE and FRR fitted and not an AFD, are summarised in the tables below (*Table 2*,

*Table **3***, *Table 4*).

They are split into:

- ***Table 2***: Marine Assemblage species, which represents the marine fish assemblage as designated under a sub feature of the Severn Estuary SAC habitat feature and a Ramsar feature. It is unique within the UK, with over 110 species listed as contributing to the designation. We have carried out detailed assessment of those species most at risk from the cooling water intake. Although blue whiting and thornback ray were screened out of our assessment of the assemblage (see report 'Fish Designations in the Severn Estuary and the approach to assessing the "notable fish assemblage"'), impacts on these species were considered by the applicant and so we have also carried a quantitative assessment on each, the results of which are included in this table.
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- ***Table 3***: Migratory Assemblage species, which represents the Migratory species assemblage and Annex II species. The migratory fish species – Twaite and Allis Shad, Salmon, Sea trout, Eel, River and Sea Lamprey are part of the migratory fish species assemblage for both the Severn Estuary SAC and Ramsar site. In addition Twaite Shad and River and Sea Lamprey are designated as features in their own right (Annex II qualifying SAC features of the Habitats Directive).
- ***Table 4***: Individual river assessment for the Migratory Assemblage species. Several rivers that drain into the Bristol Channel are important for the fish species Allis Shad, Twaite Shad, and Atlantic Salmon. As these species have a freshwater as well as marine component to their lifecycle, it is important to understand the potential impacts of any development within the estuary on these riverine populations too. Several rivers are important for River Lamprey and Sea Lamprey. However, these lampreys do not necessarily return to their river of origin to spawn and so losses have been assessed against an estimate of the Severn Estuary population (Table 3). The HRA will still consider potential impacts on individual rivers for the two lamprey species (as described in the river lamprey and sea lamprey FIATs).

A description of the tables’ contents is given in

Table ***5***. The key results are given in Column H of each table as an annual proportional loss from the relevant population. These are the results that will be considered further in the permit determination process assessments (*List A*).

The key results are expressed as:

- Predicted value results – these are the results from using our predicted value estimates for the input parameters to the Quantitative Impact Assessment Model.
- Uncertainty range results – these are the results from using our uncertainty ranges applied to each input parameter to the model via a Monte Carlo simulation.

Table 2 - Quantitative Impact Assessment Results - Marine Assemblage Species

	A	B	C	D	E	F	G	H				
Species	**No. of fish lost due to HPC Impingement**	**No. of fish lost due to HPC Entrainment**	**No. of equivalent adults lost due to HPC Impingement**	**No. of equivalent adults lost due to HPC Entrainment**	**Total No. of equivalent adults lost due to HPC Entrapment**	**Total Tonnes of equivalent adults lost due to HPC Entrapment**	**Relevant Population** SSB (t)/ *Fishery (t)*/ number of fish	**Annual proportional loss from the relevant population due to HPC Entrapment**				
								Predicted value results	Uncertainty range results			
									1st %ile	5th %ile	95th %ile	99th %ile
European sprat	1,322,637 (fish) 3,557,152 (larvae)	3,557,152 (larvae)	3,482,256	124,500	3,606,756	55.90	7,704	0.7%	0.47%	0.52%	0.98%	1.1%
Whiting	1,708,720 (fish)	-	662,984	-	662,984	197.57	2,179	9%	3.9%	5.4%	23%	31%
Dover sole	157,565 (fish) 324,176 (larvae)	1,106,693 (larvae) 991,212 (eggs)	170,362	0.02	170,362	60.14	809	7%	1.2%	1.8%	11%	15%
Atlantic cod	302,034 (fish)	-	51,648	-	51,648	245.12	1,118	22%	3.6%	5.4%	36%	52%
Atlantic herring	37,549 (fish) 221,128 (larvae)	193,487 (larvae)	114,464	267	114,731	7.46	*157*	5%	2.9%	3.2%	6.1%	7%
European seabass	23,626 (fish) 13,129,264(larvae)	6,108,346 (larvae) 9,456,586 (eggs)	14,401	0.0001	14,401	16.17	565	3%	1.3%	1.6%	4.7%	5.4%
European plaice	1,446 (fish) 550,129 (larvae)	1,300,201 (larvae)	16,630	15	16,646	5.33	1,332	0.4%	0.02%	0.04%	0.3%	0.4%
Thornback ray	2,358 (fish)	-	1,457	-	1,457	4.78	*122*	4%	1.8%	2.1%	4.7%	5.5%
Blue whiting	7,375 (fish)	-	2,862	-	2,862	0.39	514,008	0.0001%	0.00002%	0.00003%	0.00015%	0.0002%

Table 3 - Quantitative Impact Assessment Results - Migratory Assemblage Species

	A	B	C	D	E	F	G	H				
Species	**No. of fish lost due to HPC Impingement**	**No. of fish lost due to HPC Entrainment**	**No. of equivalent adults lost due to HPC Impingement**	**No. of equivalent adults lost due to HPC Entrainment**	**Total No. of equivalent adults lost due to HPC Entrapment**	**Total Tonnes of equivalent adults lost due to HPC Entrapment**	**Relevant Population** SSB (t)/ *Fishery (t)*/ number of fish	**Annual proportional loss from the relevant population due to HPC Entrapment**				
								Predicted value results	Uncertainty range results			
									1st %ile	5th %ile	95th %ile	99th %ile
European eel	341 (fish)	538,346 (glass eel)	341	32,398	33,739	10,657	545	3%	0.93 %	1.04%	5.8%	7%
Twaite shad	763 (fish)	-	117	-	117	-	86,696	0.1%	0.04%	0.06%	0.65%	1.1%
Allis shad	23 (fish)	-	9	-	9	-	1,083	0.9%	0.27%	0.37%	4.7%	8.1%
Sea lamprey	50 (fish)	-	50	-	50	-	15,269	0.3%	0.09%	0.12%	0.54%	0.73%
River lamprey	20 (fish)	-	20	-	20	-	116,109	0.02%	0.01%	0.015%	0.03%	0.04%
Atlantic salmon	76 (fish)	-	17	-	17	-	17,616	0.1%	0.0004%	0.01%	0.45%	1.6%
Sea trout	8 (fish)	-	8	-	8	-	8,750	0.1%	0.02%	0.03%	0.26%	0.4%

Table 4 - Quantitative Impact Assessment Results - Individual River Assessments for the Migratory Assemblage Species (excepting river lamprey and sea lamprey which are assessed against a general Severn Estuary population)

	A	B	C	D	E	F	G	H				
Species	No. of fish lost due to HPC Impingement	No. of fish lost due to HPC Entrainment	No. of equivalent adults lost due to HPC Impingement	No. of equivalent adults lost due to HPC Entrainment	Total No. of equivalent adults lost due to HPC Entrapment	Total Tonnes of equivalent adults lost due to HPC Entrapment	Relevant Population SSB (t)/ *Fishery (t)*/ <u>number of fish</u>	Annual proportional loss from the relevant population due to HPC Entrapment				
								Predicted value results	Uncertainty range results			
									1st %ile	5^{th} %ile	95^{th} %ile	99^{th} %ile
Twaite shad – River Wye	763 (fish)	-	117	-	117	-	<u>43,348</u>	0.3%	0.08%	0.11%	1.3%	2.2%
Twaite shad – River Usk	763 (fish)	-	117	-	117	-	<u>21,674</u>	0.5%	0.17%	0.22%	2.6%	4.4%
Twaite shad – River Severn	763 (fish)	-	117	-	117	-	<u>21,674</u>	0.5%	0.17%	0.22%	2.6%	4.4%
Allis shad – River Wye	23 (fish)	-	9	-	9	-	<u>433</u>	2%	0.68%	0.92%	12%	20%
Allis shad – River Severn	23 (fish)	-	9	-	9	-	<u>650</u>	1.5%	0.45%	0.61%	7.8%	14%
Atlantic salmon – River Wye	76 (fish)	-	17	-	17	-	<u>5,890</u>	0.3%	0.001%	0.03%	1.2%	3.9%
Atlantic salmon – River Usk	76 (fish)	-	17	-	17	-	<u>6,269</u>	0.3%	0.001%	0.03%	1.3%	4.6%
Atlantic salmon – River Severn	76 (fish)	-	17	-	17	-	<u>3,038</u>	0.6%	0.002%	0.01%	2.3%	7.6%

Table 5 - Description of Quantitative Impact Assessment Results table contents

Column	Description
Column A. No. of fish lost due to HPC Impingement	This represents the number of individual fish or larvae impinged on the Band & Drum screens that are not returned to the estuary alive (impingement mortality), over a 12 month period. For most species, this was calculated from the CIMP data, producing estimates for 2009/10. For Salmon & Sea Trout, this was calculated from the RIMP data, producing an annual mean over several years. Larvae numbers could only be calculated for certain species where adequate data was available.
Column B. No. of fish lost due to HPC Entrainment	This represents the number of individual larvae or eggs passing through the Band & Drum screens that are not returned to the estuary alive (entrainment mortality), over a 12 month period. This was calculated from survey data from 2008/9, producing estimates for 2008/9, except for European Eel which was calculated from newly submitted survey data from 2012/13, producing estimates for 2012/13. This analysis was only completed for a handful of species where adequate data was available.
Column C. No. of equivalent adults lost due to HPC Impingement	Each fish and each larva is assigned a value which equates to how many spawning adults it would have produced (Equivalent Adult Value (EAV)) if it had not been lost from the population due to impingement mortality. This was calculated from the same base data as Column A.
Column D. No. of equivalent adults lost due to HPC Entrainment	Each larva and egg is assigned a value which equates to how many spawning adults it would have produced (Equivalent Adult Value (EAV)) if it had not been lost from the population due to entrainment mortality. This was calculated from the same base data as Column B, for a handful of species where adequate data was available.

Column E. Total No. of equivalent adults lost due to HPC Entrapment	This represents the sum of the previous two columns, combining the impingement estimates with the entrainment estimates to give an overall entrapment estimate. This step was not presented within the permit variation application, but is essential for us to consider the full effect of the cooling water system.
Column F. Total Tonnes of equivalent adults lost due to HPC Entrapment	The number of equivalent adults we estimate would be lost due to the cooling water system (Column E), converted in to the equivalent weight in tonnes. This is done by multiplying up by the average weight of an adult. This has only been done for certain species where populations are normally assessed as the weight of the spawning stock, so a comparison can be made.
Column G. Relevant Population	This is the estimated size of the population from which we predict the cooling water system will remove fish. (NB: this is not an estimate of the current population.) The total losses in Column F are compared against this size of population to produce the proportional losses in Column H. Depending on the availability of information, different population units were used: • For marine assemblage species, either ICES* Spawning Stock Biomass or ICES* fisheries landing estimates were scaled to provide an estimate associated with the Bristol Channel. • For migratory assemblage and Annex II species, estimates of local rivers and estuarine populations in numbers of fish were used. • For eels, an estimate of the silver eel escapement from local rivers is used as per our regular Eel population management monitoring.
Column H. Annual proportional loss from the population due to HPC Entrapment	This represents the percentage of the population that could be lost every year. The predicted value is our best estimate of the annual loss. The other values show confidence limits, obtained by considering the variation and uncertainty in the estimate.

* The International Council for the Exploration of the Sea (ICES) is an intergovernmental marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

Comparison of Environment Agency's results with applicant's results

Although we have adopted the basis of the assessment model as it was presented in the application documentation, we have made several adjustments to the input parameters. These adjustments are explained in the suite of Technical Briefs described in *Table 1* and included:

- Raising HPB impingement samples correctly to full capacity (eg 4 cooling water pumps operating continuously).
- Selecting data from the HPB impingement estimates to reflect, where possible, the cohorts as spawned in 2009/10.
- Not applying an ebb tide bias factor to the HPB impingement estimates.
- Applying recalculated Intake Design Factors.
- Applying some adjusted FRR mortality rates.
- Applying some adjusted EAV factors using an extension to the applicant's EAV methodology.
- Including an additional EAV number to take account of the impingement on a 5mm screen.
- Including entrainment losses (through a 5mm screen) to produce entrapment losses.
- Refining the population estimates to be more relevant to the specific designated features under the Habitats Directive.

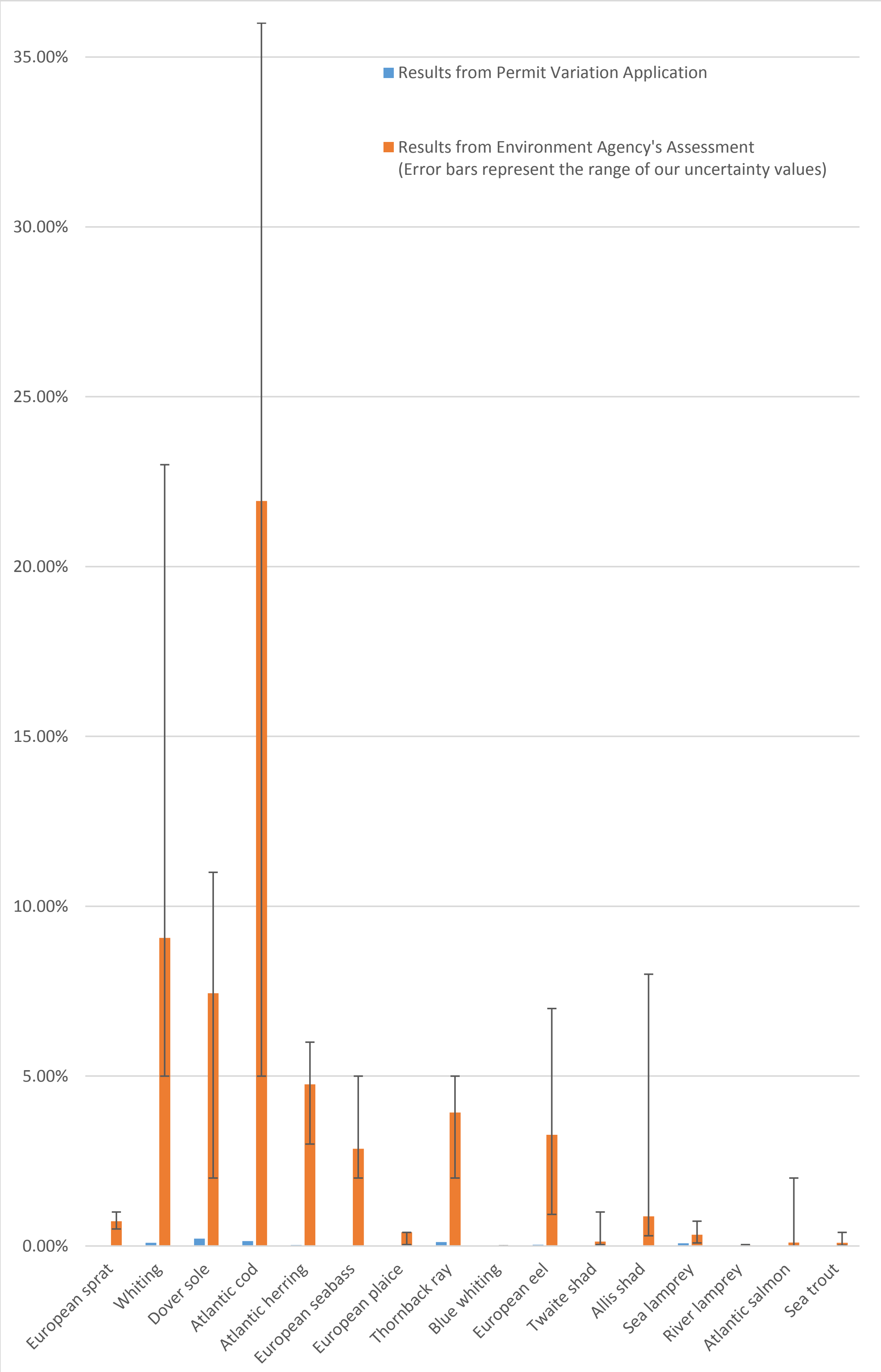
Table 6 and **Graph *1*- Comparison of Predicted Annual Proportional Losses***Graph 1* compare the applicant's Annual Proportional Losses with those from our Quantitative Impact Assessment Model. Our estimated losses from the relevant populations are much greater than the applicant's.

We are satisfied that our adjustments to the assessment model are reasonable. To aid us with this we appointed a Marine Contractor (APEM LTD) with extensive knowledge of fishery ecology, management and assessments to ensure the most up to date data and evidence were available for consideration. To ensure these adjustments were proportionate, we consulted Statutory Nature Conservation Bodies (Natural England & Natural Resources Wales) and the Marine Management Organisation (MMO), and considered carefully their advice and guidance.

Table 6 - Annual Proportional Loss Predictions Comparison

Species	Predictions from original permit application (2013)	Predictions from permit variation application (TR456, 2019)	Predicted values from EA's Quantitative Impact Assessment Model	
	Impingement only	Impingement only	Impingement only	Total entrapment
European sprat	1665.5%	-	0.7%	0.7%
Whiting	0.72%	0.090%	9%	9%
Dover sole	0.04%	0.217%	7%	7%
Atlantic cod	0.24%	0.145%	22%	22%
Atlantic herring	0.2%	0.031%	5%	5%
European seabass	-	0.011%	3%	3%
European plaice	0.00%	0.002%	0.4%	0.4%
Thornback ray	-	0.118%	4%	4%
Blue whiting	0.00%	0.000%	0.0001%	0.0001%
European eel	0.06%	0.039%	0.05%	3%
Twaite shad	0.00%	**0.011%**	**0.1%**	**0.1%**
Allis shad	0.00%	**0.017%**	**0.9%**	**0.9%**
Sea lamprey	0.27%	**0.077%**	**0.3%**	**0.3%**
River lamprey	0.01%	**0.008%**	**0.02%**	**0.02%**
Atlantic salmon	-	**>0.0086%**	**0.1%**	**0.1%**
Sea trout	-	**>0.0054%**	**0.1%**	**0.1%**
Results are expressed as an Annual proportional loss from either; an estimate of Spawning Stock Biomass (t) / predicted Fishery Landings (t) / **No. of fish with spawning population**				

Graph 1- Comparison of Predicted Annual Proportional Losses



REFERENCES

TR456 - Revised Predictions of Impingement Effects at Hinkley Point C - 2018. BEEMS Technical Report TR456 Edition 2, Revision 10. Cefas, Lowestoft (2019).

Appendix A - Quantitative Impact Assessment Input Parameters – Excel Spreadsheet